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3 **A critical perspective on the implementation of the EU Council Seveso Directives in**
4 **France, Germany, Italy and Spain.**

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23 *ABSTRACT*

24 From 1982 to 2012, an important legislation, known as Seveso Directives I-II-III and
25 amendments, was adopted in the European Union to regulate and prevent major industrial
26 accident hazards. This European legislation was transposed, applied and implemented in each
27 European Member State and after nearly forty years it is worthwhile to look back and also to
28 look forward to key issues relevant to actual Seveso implementation. Authors of this paper are
29 all members (retired or active) of the Loss Prevention Working Party of the European
30 Federation of Chemical Engineering, which started in 1971. This article examines and
31 compares, for the four EU Member States France, Germany, Italy and Spain, the structures
32 and practices for the implementing of the European rules. Difficulties, variations in
33 application and the quality of enforcement of this complex process are critically discussed,
34 including proper analysis of worked examples. Finally, a particular attention is paid to the
35 different ways in which the control and inspection practices of each of the Member States
36 concerned are implemented.

37 *KEYWORDS:*

38 Seveso legislation – implementation – inspection practices – LUP criteria

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HIGHLIGHTS

- Process safety accidents have not decreased in number nor in severity.
- The implementation of the Seveso directives has progressed over time.
- Quantitative risk analysis assessment criteria should be standardized.
- Inspection arrangements for Seveso establishments should be reinforced or improved.

80 **List of symbols and abbreviations**

81 AEGLs Acute Exposure Guideline Levels

82 AEGL 1 – Level 1 Notable discomfort, irritation, or certain asymptomatic non-sensory
83 effects. However, the effects are not disabling and are transient and reversible upon cessation
84 of exposure.

85 AEGL 2 – Level 2 Irreversible or other serious, long-lasting adverse health effects or an
86 impaired ability to escape.

87 AEGL 3 – Level 3 Life-threatening health effects or death.

88 CLP Classification, Labelling, Packaging

89 DGPR Direction Générale de la Prévention des Risques (General Directorate for Risk
90 Prevention)

91 DREAL Direction Régionale de l'Environnement, de l'Aménagement et du Logement
92 (Regional Directorate for the Environment, Planning and Construction)

93 EIA Environmental Impact Assessment

94 ERPGs Emergency Response Planning Guidelines

95 ERPG-3 is the maximum airborne concentration below which nearly all individuals could be
96 exposed for up to 1 hour without experiencing or developing life-threatening health effects.

97 ERPG-2 is the maximum airborne concentration below which nearly all individuals could be
98 exposed for up to 1 hour without experiencing or developing irreversible or other serious
99 health effects or symptoms which could impair an individual's ability to take protective
100 action.

101 ERPG-1 is the maximum airborne concentration below which nearly all individuals could be
102 exposed for up to 1 hour without experiencing more than mild, transient adverse health effects
103 or without perceiving a clearly defined objectionable odour.

104 GDP Gross Domestic Product

105 ICPE Installations Classées Pour l'Environnement (Environmentally Classified Facilities)

106 IDLH Immediately Dangerous to Life or Health (NIOSH)

107 IPPC Integrated Pollution Prevention and Control

108 KAS Kommission für Anlagensicherheit (Commission for Plant Safety)

109 LC n Lethal concentration (LC 1, LC 5, LC 50, LC 80...) means the toxic concentration in the
110 air that causes the death of n % of the affected population

111 LFL Lower Flammability Limit

112 LOC Loss Of Containment

113 LPG Liquefied Petroleum Gas

114	LUP Land Use Planning
115	RISP Port Safety Integrated Report
116	SEA Strategic Environmental Assessment
117	
118	SEI Threshold of Irreversible Effects (Seuil des Effets Irréversibles)
119	
120	SEL Threshold for Lethal Effects (Seuil des Effets Létaux)
121	SELs Threshold for significant Lethal Effects that causes the death of s % of the affected
122	population (Seuils des Effets Létaux significatifs)
123	SMS Safety Management System
124	TEEL Temporary Emergency Exposure Level
125	TEEL-1 The maximum concentration in air below which it is believed nearly all individuals
126	could be exposed without experiencing other than mild transient adverse health effects or
127	perceiving a clearly defined objectionable odour.
128	TEEL-2 The maximum concentration in air below which it is believed nearly all individuals
129	could be exposed without experiencing or developing irreversible or other serious health
130	effects or symptoms that could impair their abilities to take protective action.
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136 **1 - Introduction**

137 From a risk perspective, Seveso disaster (1976) had been a watershed and could be regarded
138 as a “black swan” just considering its legislative follow-out giving rise to specific directives
139 used as the basis of regulations also outside of the European Union (Fabiano et al., 2017).
140 Since then, an impressive number of European regulations relating to process safety and risk
141 management have evolved over time. Nevertheless, the persistence of new major accidents is
142 still notorious. For example, by limiting itself to the four countries France, Germany, Italy and
143 Spain, the table 1 summarizes an overview of some industrial accidents for the period 1970 -
144 2018.

145 *Table 1 – Overview of some industrial accidents for the period 1970 – 2018 (Extract from the*
146 *databases Aria - eMars and Zema).*

147 As it stands, it is difficult to reach a conclusion on the effectiveness of the EU Seveso
148 Directives on the incidence of accidents. Indeed, enforced rules compel companies to analyze
149 and consider critically the safety level of their plants and that is an added value of Seveso
150 Directives. The stepwise increase in comprehensiveness of the Directives is due to the
151 evolution in insight of factors of influence, sometimes becoming clear only after a disastrous
152 accident, and further to approaches that promise improvement, such as the safety management
153 system. That despite the improvements still accidents happen is due to a number of factors,
154 such as present methods do not guarantee perfect hazard identification and skip turn-arounds
155 and other abnormal situations. Risk assessment is often only qualitative and it is fallible, even
156 when it is quantitative. So, the sole risk assessment will never be sufficient to prevent
157 accidents. Further, plants become more complex due to additional requirements (e.g., energy
158 saving), new designs and technology with more automation, and aging. In the same way, all
159 aspects of human factors play a significant role in major accidents causation, as shorter time

160 on the job, less dedication, additional complications in case of outsourcing and training
161 deficiencies to name a few. Expectation is that digitalization will further improve safety, but
162 we shall have to wait and see. All this will make that a further revised version of Seveso
163 Directives may be needed.

164 This has led to the promotion of regulatory leaps that are gradually leading to tighter
165 legislation. The respective EU Seveso I – II – III Directives and their amendments have
166 therefore proposed a regulatory framework of strategic process safety and risk management
167 principles, which Member States must transcribe, apply and implement. The context of this
168 implementation obviously depends, among other things, on the various pre-existing national
169 regulations, the nature of the territories, their history and the criteria adopted in each member
170 state to give an appropriate answer to the aims of these Directives.

171 The open scientific literature contains few results on the implementation of the EU Seveso
172 directives, especially in terms of comparison between the Member States. Hawksley (1992)
173 compared the differences and contrasts in implementation of the safety reports required in the
174 EU Seveso I Directive in the Member States Germany – The Netherlands and UK. Schütz and
175 Wiedermann (1995) designed in Germany a prototype package for the hazardous incident
176 public information in the relation with the implementation of the second amendment
177 88/610/EEC of the EU Seveso I Directive. Rosen (1998) analyzed the challenge presented by
178 implementation of the EU Seveso I and II Directives in Italy. Pineau (1999) described the
179 implementation and application of the EU Seveso I and II Directives in France. Vérot (2002)
180 detailed the compliance of the French regulations with the EU Seveso II Directive. Versluis
181 (2004) showed the variability of the degree of fit in relation to the Safety Data Sheets
182 Directive in the four Member States Germany - The Netherlands - Spain and UK. Ham et al
183 (2006) compared the implementation of the EU Seveso II Directive in the Netherlands and
184 France. Pey et al. (2009) examined the main differences on European regulations in the frame

185 of Seveso Directive. Pozzo (2010) discussed in practice the concrete implementation of the
186 EU Seveso I and II Directives in an enlarged Europe. Farret (2014) reported the divergences
187 and convergences of the hazard assessment implementation in France – Germany – The
188 Netherlands and UK. Suffo and Nebot (2015, 2016) studied, within the framework of the EU
189 Seveso II Directive, the importance of the "neighbouring" factor in the implementation of
190 territorial risk in Andalusia (South Spain). Swuste and Reniers (2017) considered the
191 effectiveness of the application of European legislation in Belgium and the Netherlands.
192 Finally, more generally, Besserman and Mentzer (2017) analyzed the global process safety
193 regulations at the continental level in USA - EU - UK - China and India. In summary, with the
194 exception of the article by Swuste and Reniers (2017), the papers identified are limited either
195 to particular articles or to specific cases in the review of the EU Seveso Directives.

196 This paper is authored by four members of the Loss Prevention Working Party of the
197 European Federation of Chemical Engineering, which started in 1971 as a reaction to some
198 notable accidents by a group of motivated safety pioneers (De Rademaeker et al., 2014). The
199 focus of the paper attempts to compare, for the four EU Member States France, Germany,
200 Italy and Spain, the reality of their structures and practices for implementing European rules.
201 After this introduction the article is organized in four further sections. A first chronological
202 survey of the EU Council Seveso Directives is reported. Then, the national transposition by
203 the corresponding Member States is described together with the respective main government
204 laws and decrees, while also mentioning the competent and implementing authorities. The
205 effectiveness of the respective implementations by Member States is then gradually discussed
206 in accordance with the requirements of the EU Directives. Some examples and worked case-
207 studies showing notable variations in implementation are commented on. Next the important
208 issue of establishment inspection is analyzed to show the strengths and weaknesses of the

209 completeness of the decisions applied in the four EU Member States examined. Summary of
210 the study and concluding remarks on required future efforts are provided in the final section

211 **2 – Materials and methods**

212 In order to meet the objectives of the critical comparison of the implementation of the EU
213 Council Seveso directives in the four countries concerned, official documents available to the
214 public both at European and national level were examined.

215 The Aria, e-Mars and Zema databases made it possible to inventory the main industrial
216 accidents during the period 1970 - 2018.

217 The three EU Seveso Directives were consulted in the Official Journals of the European
218 Community (OJEC).

219 The evaluation reports on the practical implementation, compiled from each report required
220 and submitted by the Member States and drawn up by the EU Council during the period 1988
221 - 2017, were studied. The content and quality of these reports showed the gradual
222 improvement of implementation over time.

223 The crucial issue of control and inspection practices of Seveso establishments was first
224 reviewed by examining the specific inspection procedures implemented in each Member State
225 concerned. Then the detailed compliance of the four Member States with the European
226 inspection requirements was based on the feedback reports from EU Council.

227 Finally, relevant case studies are presented, either original, or taken from the scientific
228 literature

229

230 **3 – Chronological survey of the EU Council Seveso directives**

231 3.1 – EU Seveso I Directive (OJEC, 1982)

232 As a consequence of the pressure relief venting following a reactor runaway accident in an
233 ICMESA plant (belonging to the Roche pharmaceutical group) at Seveso (Italy) in 1976, the
234 EU Council Directive 82/501/EEC (known as the EU Seveso I Directive) on major-accident
235 hazards of certain activities was adopted in 1982 by the Council of European Union in order
236 to prevent and control such accidents. This legislation required, amongst other things:

- 237 - The production of a safety report detailing how major accidents are prevented and
238 controlled.
- 239 - An assessment of the possible major accidents, their likely consequences and
240 approximate frequencies.
- 241 - The development of on-site emergency plans.
- 242 - The production of an off-site emergency plan by the local authorities responsible for
243 such matters.

244 Following the MIC release tragedy at Union Carbide plant in Bhopal (India) in 1984 (Palazzi
245 et al., 2015) and the fire in a storage facility of Sandoz company in Basel (Switzerland) in
246 1986, with the release of hazardous chemicals into the Rhine river and transboundary
247 environmental damages (Brüggemann and Halfon, 1990), three amendments to the Seveso I
248 Directive were published, namely: Directive 87/216/EEC (OJEC, 1987) - Directive
249 88/610/EEC (OJEC, 1988) and Directive 91/692/EEC (OJEC, 1991). These amendments
250 aimed at broadening the scope of the Directive, in particular to clarify the inclusion of storage
251 of dangerous substances in the scope of the directive and include information to be given to
252 the public in the event of an accident.

253

254 3.2 – EU Seveso II Directive (OJEC, 1997)

255

256 The Directive “Seveso I” was finally subjected to a fundamental review by the European
257 Commission. Indeed, a number of problem areas were identified giving rise to set up a new
258 Directive (96/82/EC) known as Directive “Seveso II” and replacing the precedent. The new
259 legislation came into force across member states in 1999. It is based on the experiences
260 accumulated during the implementation of Seveso I, in particular from lessons learnt from
261 accidents. It includes a revision and extension of the scope; the introduction of new
262 requirements relating to safety management systems; emergency planning and land-use
263 planning and a reinforcement of the provisions on inspections to be carried out by member
264 states. The aim of this Directive is on the one hand with the prevention of major hazards
265 involving dangerous substances and on the other hand with the limitation of consequences of
266 accidents that still may occur with impacts for people and environment.

267 There are a number of ways which the new directive differs from the old:

268 - The scope of Seveso II has been broadened and simplified, referring to the presence of
269 dangerous substances at establishments in excess of threshold quantities, while Seveso
270 I referred either to listed substances in connection with certain industrial activities or
271 to the separate storage of substances. It covers both industrial activities as well as the
272 storage of dangerous chemicals in quantities above listed threshold limits. The
273 Directive can be viewed as providing for three levels of proportionate controls, where
274 larger quantities mean more controls. In this sense a company who holds a quantity of
275 dangerous substance less than the lower threshold levels given is not covered by the
276 directive. On the other hand, companies that hold a larger quantity of dangerous
277 substance, which is above the lower threshold contained in the Directive, will be
278 covered by lower tier requirements. Finally, companies that hold quantities of
279 dangerous substances above the upper threshold contained in the Directive will be
280 covered by all requirements of the Directive.

- 281 - In relation with hazardous substances, the Seveso II Directive introduced a significant
282 difference in relation to the previous Directive as it considers that the “*presence of*
283 *dangerous substances shall mean the actual or anticipated presence of such*
284 *substances in the establishment, or the presence of those which it is believed may be*
285 *generated during loss of control of an industrial chemical process*”. Being this latest a
286 clear concern in terms of potential hazards, but hardly considered in implementation
287 guidance’s, inspections and controls.
- 288 - The measures to be undertaken by operators of establishments to prevent and limit the
289 consequences of major-accidents have been redefined and now include the setting up
290 of a “Major-Accident Prevention Policy”. The intention is to emphasize the
291 importance of setting up safety management systems as important elements to
292 promote high levels of protection.
- 293 - Increased emphasis on measures to minimize environmental impacts of major-
294 accidents including emergency preparedness, land-use planning, identification of
295 possible domino effects and information to public.
- 296 - To obtain uniform levels of protection throughout the European Union, the Member
297 States are required to ensure that the Competent Authorities assess the Safety reports
298 and in particular are required to organize a system of ongoing inspections.
- 299 - The purpose of the Directive is the prevention of major accidents and to harmonize the
300 efforts in this field within the EU. Seveso II is related to the new EU legislation on the
301 protection of safety and health of workers. The Directive contains general and specific
302 obligations on both operators and Member States Authorities falling into the
303 categories of the two aims of the Directive, *i.e.* to control measures aimed at the
304 prevention of major accidents and to control measures aimed at the limitation of

305 consequences of major accidents. One obligation of Operators of establishments of
306 utmost importance is the production of a Safety Report demonstrating that.

307 - A major accident prevention policy and a safety management system for
308 implementing it must be in effect.

309 - Major accident hazards have to be identified and necessary measures have to be taken
310 to prevent such accidents and limit their consequences for people and environment.

311 Adequate safety and reliability have to be incorporated into the design, construction,
312 operation and maintenance linked to major accident hazards.

313 - Internal emergency plans have to be drawn up and information has to be supplied to
314 the Authorities enabling an emergency plan to be drawn up. Notwithstanding its
315 advance when compared to the older Directive, important areas were excluded from
316 the scope of Seveso II including nuclear safety, the transport of dangerous substances
317 and intermediate temporary storage outside establishments and the transport of
318 dangerous substances by pipelines.

319 Wettig et al. (1999) have explained in detail the background and content of the Seveso I and II
320 Directives.

321 In the light of more recent industrial accidents, for example Enschede (2000), Baia Mare
322 (2000) and Toulouse (2001), the Seveso II Directive was extended by Directive Amendment
323 2003/105/EC (OJEC, 2003) to cover risks arising from storage and process activities in
324 mining, from pyrotechnic and explosive substances and from storage of ammonium nitrate
325 and ammonium nitrate based fertilizers. Vierendeels et al (2011) analyzed the parameters of
326 the emergence of the amendment, which influenced change during the legislative process.

327

328 3.3 – EU Seveso III Directive (OJEC, 2012)

329 The Seveso-III-Directive (2012/18/EU) aims at the prevention of major accidents involving
330 dangerous substances. However, as accidents may nevertheless occur, it also aims at limiting
331 the consequences of such accidents not only for human health but also for the environment.
332 The Directive covers establishments where dangerous substances may be present (e.g. during
333 processing or storage) in quantities exceeding certain thresholds. Excluded from the Directive
334 are certain industrial activities which are subject to other legislation providing a similar level
335 of protection (e.g. nuclear establishments or the transport of dangerous substances).
336 Depending on the amount of dangerous substances present, establishments are categorized in
337 lower and upper tier and the latter are subject to more stringent requirements. The legal
338 framework established by the Directive creates a continuous improvement cycle of
339 prevention, preparedness and response to major accidents. The cycle is closed by provisions
340 on lesson learning. Operators are obliged to take all necessary measures to prevent major
341 accidents and to limit their consequences for human health and the environment. The
342 requirements include:

- 343 -Notification of all concerned establishments (Article 7);
- 344 -Deploying a major accident prevention policy (Article 8);
- 345 -Producing a safety report for upper-tier establishments (Article 10);
- 346 -Producing internal emergency plans for upper tier establishments (Article 12);
- 347 -Supply of information in case of accidents (Article 16).

348 Member States need to ensure that a number of requirements are fulfilled, those include:

- 349 -Establishing external emergency plans for upper tier establishments (Article 12);
- 350 -Considering major accident prevention in land-use planning policies for the siting of
351 establishments (Article 13);
- 352 -Making relevant information publicly available (Article 14);

353 -Ensuring that any necessary action is taken after an accident including emergency measures,
354 actions to ensure that the operator takes any necessary remedial measures and informing the
355 persons likely to be affected (Article 17);

356 -Reporting accidents to the Commission (Article 18);

357 -Prohibiting the unlawful use or operation of establishments (Article 19);

358 -Conducting inspections (Article 20).

359 Member States may maintain or adopt stricter measures than those contained in the Seveso
360 Directive.

361 Citizens' rights must be respected:

362 -The public concerned needs to be consulted and involved early in the decision making for
363 specific individual projects (Article 15);

364 -Subject to the conditions outlined, Member States need to make available any information
365 held pursuant to the Seveso Directive (Articles 14 and 22 under consideration of Article 11);

366 -Access to justice needs to be granted on the cases listed in Article 23.

367

368 **4 – National transposition by the States**

369 The European Commission expects that the directives are transposed into the national
370 regulations of the various member states. On the one hand, this requirement, which seemed
371 simple at first sight, has in fact created many difficulties during its effective application.
372 Indeed, a directive can either be translated verbatim, or all articles as parts included in pre-
373 existing legislation, which must necessarily be up to date.

374 On the other hand, the diversity of regulatory authorities in Member States may also be a
375 potential source of transcription variability. Some countries have already established

376 structured procedures. Others are in the process of drafting new rules or may not yet have
377 structure and legislation to estimate major accident risks.

378 For the record, a brief reminder of some of the definitions used in the paper seems useful.
379 First, Council regulations obtain direct legal effect, immediately after their entry in force and
380 need no transposition. On the other hand, transposition of a directive is the legal or regulatory
381 act by which an EU directive is incorporated into the national body of laws. Application is the
382 practical enforcement of the national transposing provisions to a concrete situation or to a
383 number of situations. Implementation is the general term covering both transposition and
384 application.

385 4.1 - Governmental laws and regulatory sub- and infra-structures

386 The EU Commission is responsible for monitoring the application of EU Community law in
387 the Member States. It must therefore first check that the Community directives are correctly
388 and fully transposed into national regulatory and administrative legislation.

389 Table 2 shows for each Member State the hierarchy of the various transposition regulations
390 adopted such as Law, Act, Ordinance, Decree, Amendment and Circular.

391 *Table 2 – Inventory of the national laws and decrees transposing the EU Seveso regulations.*

392 Table 3 shows for each Member State the different national and regional authorities
393 responsible for the transposition and implementation of the EU Seveso Directives. It should
394 be noted that, for France, the application is strictly in accordance with national directives, the
395 Prefect being the guarantor at the departmental level. On the other hand, for Germany, Italy
396 and Spain, the duality of Nation - Region or Province is clearly marked. Germany is a federal
397 country composed of 16 Länder, Italy has 20 Regions and Spain has 17 Autonomous
398 Communities. The relationship between the national level and the respective Länder, Regions
399 and Communities is regulated. For example, all German countries (16 Länder) like North-

400 Rhine Westphalia (Stuermer, 2019) and Sachsen (Gamer, 2015), Catalonia (Segui et al, 2014)
401 in Spain and Lombardy (Pozzo, 2009), Piedmont (Camuncoi et al, 2013) in Italy retain local
402 responsibility, which can result in differences in the way situations are assessed at the
403 territorial level.

404 *Table 3 – Main competent and implementing authorities responsible for the application of the*
405 *EU Seveso I – II and III directives.*

406 4.2 – Effectiveness of the transposition

407 The application of the process of transposing the EU Seveso I Directive into Member States'
408 legislation has often been seen as difficult. The final date for transposition was fixed on 08
409 January 1984. Between 1982 and 1991 this Directive was amended three times in an effort to
410 clarify its provisions and in response to the concerns of the Member States. This situation has
411 therefore naturally complicated and delayed the transposition, but also the application and
412 implementation of the EU Seveso I Directive in the four states concerned.

413 As an example, the state of transposition of EU Seveso I Directive 82/501/EEC (as amended)
414 within the European Community was as follows (COM, 1994):

415

416 France

417 Transposition of the second amendment has been carried out by administrative instruction.
418 Public information is already freely available and the public have access to the safety report
419 produced, with the exception of certain confidential information. Information to June 1993
420 indicated that 377 establishments were covered by the provisions of Article 5 of Council
421 Directive 82/501/EEC including the additional establishments covered as a result of the
422 second amendment.

423

424 Germany

425 Transposition of the second amendment has been carried out by the amended version of the
426 Twelfth Ordinance implementing the Federal Emission Control Act (Major Accident
427 Ordinance) of 20 September 1991. Approximate information received up to July 1990
428 indicated 283 establishments were covered by the provisions of Article 5 of Council Directive
429 82/501/EEC.

430 Since implementation of the second amendment and after re-unification of Germany, up to
431 date information is not available.

432

433 Italy

434 Work to prepare for the transposition of the second amendment has been underway for some
435 time but no detailed and up to date information is available. Information received for the end
436 of 1992 indicated that 329 establishments were covered by the requirements of Article 5 of
437 Council
438 Directive 82/501/EEC.

439

440 Spain

441 Transposition of the second amendment was completed by Royal Decree 952/1990.
442 Information for the end of 1992 indicated approximately 270 establishments were covered by
443 Article 5 of Council Directive 82/501/EEC.

444

445 Subsequently, the deadline for transposition of the EU Seveso II Directive was set at 3
446 February 1999, 24 months after the date of entry in force. The practice was facilitated for the
447 four Member States concerned, as its initial content was much more completed and detailed
448 than the drafting of the previous Directive. However, two factors have nevertheless disrupted

449 the actual transposition timetable in different ways. On the one hand, delays were noted in
450 transposition.

451 For example, even in the simple case of the transposition of the Safety Data Sheets Directive,
452 the different resilience in time of Germany and Spain was respectively 29 months and 25
453 months delay after the required date (Versluis, 2003).

454 On the other hand, some infringements for failure to comply have slowed down transposition.
455 For example, the European Commission has initiated an infringement procedure against
456 Germany for excessive delays in transposition due to conflicts of opinions regarding the
457 procedures adopted between the German Federal Ministry responsible for adapting the legal
458 framework (Main decree in May 2000) and the Länder (having the responsibility to
459 implement the established regulations). As a result, all the requirements were not fully
460 transposed until 2003 (Pozzo, 2009).

461 Finally, EU Seveso III does not make any substantive changes to the existing national rules.
462 Rather, it aims to improve their coherence and clarity and to achieve better coordination with
463 other Community legislation and to the harmonization with the newly developed UN Globally
464 Harmonized System of Classification and Labelling of Chemicals (GHS) according to
465 Chapter 19 plan of Agenda 21 approved at the 1992 Rio UN Conference on Environment &
466 Development, concerning “Environmentally Sound Management of Toxic Chemicals”.

467 In the next chapters of this paper, the evaluation of the implementation of the directives will
468 take precedence in the comparison of the enforcement of the laws and articles concerned.

469

470 **5 – Practical implementation by the concerned states**

471 After the transposition stage, the implementation of each of the articles of the EU Seveso
472 Directives and their amendments must be applied by each Member State. The completeness
473 and effectiveness of this implementation exercise is analysed and evaluated by the EU

474 Council on the basis of the periodic reports prepared by each Member State. After a long and
475 difficult period of breaking-in of this procedure for the application of the EU Seveso I
476 Directive, a gradual and continuous improvement of the implementation has been observed
477 over time for the other two EU Seveso II and III Directives.

478 5.1 – National implementation of the EU Seveso I directive

479 Article 18 of the EU Seveso I directive provides, that five years after notification of the
480 Directive, a report on its application must be drawn on the basis of the information reported
481 by the Member States. The cut-off date was set at 31 October 1987. Most of the summary of
482 the content of this first report published on 18 May 1988 is presented for each Member State
483 (COM, 1988):

484 France

485 French legislation on major-accident hazards predates the Directive. It is therefore not
486 surprising to note that there are some differences, e.g. in the definition of "industrial activity".
487 The authorization procedure covers a much wider field than that coming under Article 5 of the
488 Directive. It is felt that more inspectors are needed.

489

490 Germany

491 The Federal German measures implementing the Directive were introduced practically at the
492 same time as the Directive. Manufacturers of dangerous installations subject to the twelfth
493 Ordinance of the Immission Control Act have had time to produce the reports on safety and
494 the on-site emergency plans. In respect of some substances there were stricter provisions
495 (lower threshold quantity installations) than those provided for in the Directive. Nevertheless,
496 there were still some differences between the twelfth Ordinance of the Immission Control Act
497 and the Directive. For instance there is no reference to the 500 meters rule or the derogations

498 provided for in certain cases. The question remains whether the provisions on informing the
499 public are adequate. However, since the accident in Basel, a proposal amending the twelfth
500 Ordinance has been drawn up with a view to tightening up certain provisions. On the practical
501 level it is felt that there should be more and better-qualified inspectors and that there is a need
502 for guidelines on general administrative and enforcement practices, examining and drawing
503 up the safety reports and examining the in-company realization of the alarm- and emergency
504 plans (which was realized by appointing coherent administrative regulations for the Major
505 Accident Ordinance).

506

507 Italy

508 Notwithstanding the preliminary adoption of some generic legislative issues on the topic, the
509 Directive has been transposed into Italian law within a comprehensive and systematic
510 framework only in 1988, by the adoption of DPR 175, i.e. with a four years' delay with
511 respect to the deadline posed by the Directive. For this reason, the Decree 175/1988 enforced
512 also the subsequent Directive 87/216/CEE. Compared to other Countries, a sound technical
513 approach in the Directive application was enforced in Italy, by identifying an obligation of
514 declaration along with the notification one, foreseeing several authorities as responsible for
515 the overall application of the Directive. The following Prime Minister decree DPCM 31
516 March 1989 provided relevant technical guidelines for drawing up safety reports and carrying
517 out authority preliminary examinations. Unfortunately, other regulatory and administrative
518 acts in the form of Decrees and Regulations by various Ministries were not promptly issued,
519 even though for example art. 12 of DPR 175 envisaged legislative acts pertinent general
520 safety standards and identification of areas with a high concentration of industrial activities. A
521 more in-depth view on the Italian perspective allows evidencing several shortfalls of the
522 Italian regulatory texts, due to its intersections with other national legislations that were

523 neither repealed, nor amended, thus causing difficulties in the Directive interpretation and
524 practical application.

525

526 Spain

527 For Spain the Directive entered in force on 1st January 1986, when the country only recently
528 acceded to the European Communities. No written report was then transmitted to the
529 Commission. According to information passed on orally to the Commission by the Spanish
530 authorities, a Royal Decree has been drafted and should be adopted in the near future.

531

532

533 In reality, little information is available from Member States on the current state of
534 implementation Council Directive 82/501/EEC and its amendments. This is mainly due to the
535 fact that the powers initially granted to the Commission were not sufficient to enable it to
536 require the necessary information to effectively monitor the practical implementation of the
537 Directive. This problem is fixed in the current version of the proposal (COM 1994 4 final).

538

539 Other evaluation reports were then successively published for the respective periods 1994 –
540 1996 (OJEC, 1999, C 291), 1997 – 1999 (OJEC, 2002, C 28). For example, a verbatim extract
541 summarizes the content for the period from 1994 to 1997 for each Member State:

542 France

543 *“63,000 establishments are covered by the Law of 16 July 1976 and are subject to*
544 *authorization. The authorization request must include, in particular, an impact assessment*
545 *and a risk assessment. These studies are crucial in implementing the prevention of major*
546 *accidents in terms of risk reduction at source, emergency planning, control of urbanization,*
547 *and information of the public”.*

548 Germany

549 *“The German implementation of the Seveso-I Directive, the “Störfall-Verordnung” does not*
550 *refer to sites, but to installations. Therefore, all the answers given to the 1994-1996*
551 *questionnaires refer to installations. Installations covered by the “Störfall-Verordnung” are*
552 *subject to a permitting process in accordance with the Immission Control Act and the 9th*
553 *Ordinance of the Immission Control Act (at this time named “Fundamentals of the Approval*
554 *Procedure”) before they might be constructed, operated or major changes conducted. Within*
555 *this permitting procedure the safety reports - if legally required - are examined and, where*
556 *appropriate, formal additional requirements are defined or other legal action is taken by the*
557 *responsible authorities for the permitting process. The safety reports are also a very*
558 *important instrument for the further inspection of competent authorities and for the*
559 *evaluation of major changes of installations in the related permitting process.*

560 *Data concerning internal and external emergency plans have not been collected separately so*
561 *far, as the responsibility for internal emergency plans lie by the operator of installations*
562 *(latter Establishments) and the responsibility for external emergency plans by the Countries*
563 *(Länder) or the municipalities respectively. However, all installations coming under Article 5*
564 *require an internal emergency plan, which is prepared in consultation with the responsible*
565 *administration for external emergency plans and controlled by the competent authorities*
566 *during their ongoing inspections”.*

567 Observations

568 In the period under review, there were no essential changes with regard to the Major Accident
569 Control Policy of Germany. The number of installations, which fall into the range of the
570 Störfall-Verordnung (Major Accident Ordinance) was subject to more or less considerable
571 changes, when new Seveso-Directives with newly defined scopes of application (strongly
572 influenced by new annexes for the dangerous substances inventory) were transposed to

573 German law. But this was usually soon consolidated, once the implementing ordinance was
574 adopted. Now that the German unification process and the related reorganization of industry
575 in the eastern Countries have long been completed, the requirements of the Seveso Directive
576 are now since many years qualitatively and quantitatively fulfilled. Moreover, German
577 regulations exceeded the requirements of the Directive at many points.

578 Germany has since brought its national legislation in line with the Seveso Directive and
579 stepped back from Seveso-Directive exceeding regulations which led to intense discussions in
580 the relevant committees and bodies and led to an infringement procedure initiated by the
581 Commission for delayed implementation years ago.

582 Italy

583 *“Problems were experienced in the implementation of the DPR 175/88 which transposes the*
584 *Seveso Directive into national law. As a result of this, the responsibility for the evaluation of*
585 *the safety report was decentralized to a local level, thus ensuring that the work was carried*
586 *out in the best possible manner”.*

587 Spain

588 *“The answers given by the Dirección General de Protección Civil in relation to the report of*
589 *1994 concerned 75% of the industrial activities covered by the Seveso Directive and therefore*
590 *this information should be taken as provisional. The information given for 1995 and 1996*
591 *concerned 92% of the industrial activities.*

592 *In Spain, the questionnaire was sent to 19 regional autonomous communities and it is*
593 *important to stress that in many cases some of the questions were not well understood.*
594 *Therefore, the data given for the year 1994 by the autonomous communities covered only*
595 *75% of the total number of sites while in the years 1995 and 1996, the percentage of sites*
596 *covered was 92%”.*

597

598 Globally the EU Seveso I Directive and its amendments have been successfully transposed
599 into national laws, regulations and administrative provisions in the four Member States.

600 During the reporting period, the practical implementation and enforcement of the EU Seveso I
601 Directive has significantly improved across the Member States. This is shown in particular
602 by:

603 - the growing number of safety reports received (from 2,942 in 1994 to 3,209 in 1996)

604

Year	France	Germany	Italy	Spain	Total
1994	633	1,773	418	118	2,942
1996	720	1,909	430	150	3,209

605

606 - the growing number of safety reports examined (from 1,638 in 1994 to 1,799 in 1996)

607

Year	France	Germany	Italy	Spain	Total
1994	no data	1,544	no data	94	1,638
1996	no data	1,582	84	133	1,799

608

609 - the growing number of requests or legal actions taken by competent authorities
610 following the examination of safety reports (from 76 in 1994 to 134 in 1996)

611

Year	France	Germany	Italy	Spain	Total
1994	no data	no data	20	56	76
1996	no data	no data	84	50	134

612

613 - the growing number of internal emergency plans (from 878 in 1994 to 950 in 1996)

614

Year	France	Germany	Italy	Spain	Total
1994	341	no data	418	119	878
1996	370	no data	430	150	950

615

616 - the growing number of external emergency plans (from 494 in 1994 to 519 in 1996)

617

Year	France	Germany	Italy	Spain	Total
1994	227	no data	190	77	494
1996	227	no data	179	113	519

618

619 - the variation of the total number of sites (from 3,336 to 2,797)

620

Year	France	Germany	Italy	Spain	Total
1994	383	2,388	418	147	3,336
1996	392	1,828	430	147	2,797

621

622 The variations of the number of sites are not easy to compare as Member States had
623 different approaches. For example, the large number of sites in Germany is mainly due
624 to the fact that, under the Seveso I Directive, each installation of an industrial
625 establishment has been counted under Article 1 of the Seveso I Directive, while the
626 other Member States define an establishment composed of different installations as a
627 single site. It is worth noting the potential confusion introduced by this ambiguity.
628 However, in the Seveso I Directive, the term "establishment" was not used but the
629 term "installations" with a list in Annex 1. The term "establishment" was introduced

630 only for the first time in Seveso II - i.e. after 1996 - and considerably changed the
631 scope and number of units considered, as establishments often include more than one
632 installation. For the future, it should be noted that the Seveso II Directive used the
633 unequivocal system based on establishments.

634

635 - the growing number of sites inspected (from 138 in 1994 to 255 in 1996)

636

Year	France	Germany	Italy	Spain	Total
1994	no data	no data	40	94	138
1996	no data	no data	179	76	255

637

638 - the growing number of sites that have given information to the public (from 1,951 in
639 1994 to 2,207 in 1996).

640

Year	France	Germany	Italy	Spain	Total
1994	252	1,464	210	25	1,951
1996	252	1,612	319	24	2,207

641

642 5.2 - National implementation of the EU Seveso II directive

643 The responses provided by the four Member States to the implementation questionnaire of the
644 EU Seveso II Directive were mostly complete. Overall the EU Seveso II Directive was mostly
645 well implemented by the Member States. From the responses provided by Member States it
646 appears that processes and structures are in place for implementing the Directive and only
647 Italy is considered to have difficulties relating to the implementation of key features of the
648 Directive.

649 After the publication of several interim evaluation reports of the EU Seveso II Directive
650 (Reports C 2010, C 2013 and COM 2017), this section presents a summary of the 5th and last
651 report published for the period 2012 - 2014 (Calero, 2017) and a comparison with previous
652 reporting periods. The importance of the existence of many Seveso establishments in France,
653 Germany, Italy and Spain, as shown in table 4, militates for an indispensable evaluation of the
654 strengths and weaknesses of the practice of this implementation.

655 Table 4 summarizes for each given Member State the evolution of the number of upper-tier
656 establishment through the reporting period and shows that an overall increase can be observed
657 in the four Member States. Here at this point, it should be well considered that in 2012 the
658 Seveso Directive was changed to the Seveso III Directive, with considerable impact on the
659 scope, respectively the number of affected establishments as the list of dangerous substances
660 in Annex I was altered and the CLP-System (Classification, Labelling, Packaging) introduced.
661 In 2014 Germany has the highest number of Seveso establishments with 1,141 upper-tier
662 establishments. It is followed by France with 639 and Italy 567.

663 *Table 4 – Evolution of the number of upper-tier Seveso establishments (2005 – 2014).*

664 The summary of the practical implementation is now verbatim recapitulated for each Member
665 State (Calero, 2017):

666 France

667 *“The French response indicates that the provisions of the EU Seveso II Directive are mostly*
668 *fully implemented, with some issues identified with key aspects of the Directive in particular*
669 *the lack of external emergency plans for 75 establishments, the lack of testing of external*
670 *emergency plans for 45 establishments and the lack of annual inspection in 28 upper tier*
671 *establishments.*

672 *In France, there were a total of 1,178 establishments subject to the provisions of the EU*
673 *Seveso II Directive in 2014, of which 639 (54% of the total) were upper-tier establishments.*
674 *France reports that almost all upper-tier establishments apart from 23 had an external*
675 *emergency plan. For these, the competent authorities decided that an external emergency*
676 *plan was not needed in accordance with Article 11.6 of the EU Seveso II Directive. For an*
677 *additional 75 establishments, no plan had been drawn up by the end of the reporting period,*
678 *however the response indicated that the plans were either being produced or pending upon*
679 *the submission of further information in order to determine the required protective measures.*
680 *As such, it appears that this aspect of the EU Seveso II Directive will be soon in compliance.*
681 *At the end of the reporting period, 45 upper tier establishments' external emergency plans*
682 *had not been tested which does not appear to comply with the requirements of the EU Seveso*
683 *II Directive.*
684 *Inspections were carried out at least once during the reporting period for 100% of upper-tier*
685 *sites and 98% of lower-tier sites. Annual inspections were held in 611 establishments,*
686 *representing 96% of total upper tier establishments. The fact that 4% of upper tier*
687 *establishments were not inspected annually is highlighted as an aspect of the implementation*
688 *of the Directive that may warrant further investigations”.*

689

690 Germany

691

692 *“The German response indicates that the provisions of the EU Seveso II Directive are almost*
693 *fully implemented. The main gap observed relates to the large number of upper-tier*
694 *establishments that were not inspected annually, with some not inspected at all during the*
695 *reporting period. Note that Germany uses a systematic appraisal of major accident hazards to*
696 *plan inspections. As such annual inspections are not required so this does not constitute a*

697 *compliance issue but rather a potential issue that might need further checks. In addition, for*
698 *83 upper-tier establishments external emergency plans had not been produced at the end of*
699 *the reporting period.*

700 *In Germany, there were a total of 3,264 establishments subject to the provisions of the EU*
701 *Seveso II Directive in 2014, of which 1,141 (34% of the total) were upper-tier establishments.*
702 *Germany reported that all upper-tier establishments apart from 165 had an external*
703 *emergency plan. For 82 upper-tier establishments the German authorities decided that an*
704 *external emergency plan was not needed based on strict criteria including quantities,*
705 *properties and state of the hazardous substances and location of the establishment. For an*
706 *additional 83 upper-tier establishments external emergency plans had not been produced at*
707 *the end of the reporting period. The main reasons for plans not being produced include cases*
708 *where establishments recently changed or were recently classified as upper-tier and where*
709 *the draw up of the plans or the safety report required recently are still in progress.*
710 *Furthermore, Germany added that it is possible to partially impose upper-tier requirements*
711 *on establishments which would, according to the Directive, only have to be classified as*
712 *lower-tier. Such establishments have been listed as upper tier but would not be required to*
713 *meet all the requirements of an upper-tier establishment. For example, it may not be required*
714 *to produce an external emergency plan. At the end of the reporting period, 16% of upper tier*
715 *establishments' external emergency plans had not been tested. Germany explained that for*
716 *most of these establishments the 3-year deadline had not expired yet, because the*
717 *establishments became newly classified as upper-tier during the reporting period. For others,*
718 *the testing was being delayed due to changes to the establishments. As such this does not*
719 *appear to constitute a lack of compliance with the requirements of the EU Seveso II Directive.*
720 *Inspections are planned based on a systematic appraisal of major-accident hazards; as such*
721 *there is no obligation to inspect upper-tier establishments annually. Inspections were carried*

722 out at least once during the reporting period for 86% of upper-tier sites and 68% of lower-
723 tier sites. Annual inspections were held in 422 establishments, representing 37% of total
724 upper tier establishments. While not a compliance issue, the fact that 14% of upper tier
725 establishments were not inspected over the reporting period is highlighted as an aspect of the
726 implementation of the Directive that may warrant further investigations and the German
727 competent authorities confirmed that this point would be investigated further”.

728

729 Italy

730 “The Italian response indicates that most of the provisions of the Seveso II Directive are
731 implemented. However, there were issues identified with some of the key provisions of the
732 Directive, related in particular to the large number of upper-tier establishments that were not
733 inspected annually and the number of external emergency plans not adopted or tested.

734 In Italy, there were a total of 1,112 establishments subject to the provisions of the Seveso II
735 Directive in 2014, of which 567 (50% of the total) were upper-tier establishments. Italy
736 reported that all upper-tier establishments apart from 4 were required to have external
737 emergency plans. Italy provided additional information to explain that these external
738 emergency plans were not drafted because the competent authorities assessed that major
739 accidents could not be reasonably foreseen (in accordance with Article 11.6 of the Directive).
740 For 66 establishments, the external emergency plans, while required, were not drafted which
741 does not comply with the requirements of Article 11.1. At the end of the reporting period, 302
742 upper tier establishments’ external emergency plans had not been tested. This represents
743 more than half of the total number of upper-tier establishments in Italy (53%). It is unclear
744 why this requirement of the EU Seveso II Directive has not been implemented.

745 Inspections were carried out at least once during the reporting period for 20% of upper-tier
746 sites and 49% of lower-tier sites. Annual inspections were held in none of the upper-tier

747 establishments. The data reported on inspections are particularly low, especially considering
748 that Italy is the Member State with the third highest number of Seveso establishments in
749 Europa. It reflects difficulties encountered in applying the requirements of the Directive at
750 national level and it may be necessary to investigate the need for additional support to Italy
751 with these aspects. These difficulties were confirmed by the Italian Member State competent
752 authorities that indicated that steps were taken to address them”.

753

754 Spain

755 “In Spain, there were in 2014 a total of 832 establishments of which 377 (45% of the total)
756 were upper-tier establishments. Spain reported that all upper-tier establishments apart from 4
757 were required to have an external emergency plan. Plans had not been drafted for 32
758 establishments. There was no information provided to understand why this is the case.

759 At the end of the reporting period, 210 upper tier establishments’ external emergency plans
760 had not been tested. This does not appear to comply with the requirements of the EU Seveso II
761 Directive. It is unclear whether inspections are planned based on a systematic appraisal of
762 major-accident hazards or not. Authorities carried out, on average, inspections at least once
763 during the reporting period in 78% of upper-tier sites and in 56% of lower-tier sites during
764 the reporting period. Annual inspections were held in 192 upper tier establishments,
765 representing 51% of total upper tier establishments. This relatively low number of upper-tier
766 establishments inspected annually may not be an issue (depending on how inspections are
767 planned); however, it might be useful to verify this is the case. However, the fact that 22% of
768 upper tier establishments were not inspected at all during the reporting period might indicate
769 difficulties encountered in applying the requirements of the Directive at national or regional
770 level”.

771

772 In summary, France, Germany and Italy provided a complete answer, while Spain answered
773 the majority of the questions, but did not give an answer to the question concerning the
774 inspection program based upon a systematic appraisal. The French response indicates that the
775 provisions of the Seveso II Directive are almost fully implemented. The main problems
776 identified show that external emergency plans for 45 upper threshold establishments were not
777 tested during the reporting period and that for 75 establishments, no plan had been established
778 by the end of the reporting period.

779 The German response indicates that the provisions of the Seveso II Directive are almost fully
780 implemented with only minor aspects outstanding. The main issues identified point out that
781 no compliance issue has been identified, rather it was unclear why a share of upper tier
782 establishments (14%) were not inspected during the reporting period. Note that Germany uses
783 a systematic appraisal of major accident hazards to plan inspections, as such annual
784 inspections are not required so this does not constitute a compliance issue but rather a
785 potential issue that might need further checks. In the same way an additional 83 upper-tier
786 establishments external emergency plans had not been produced at the end of the reporting
787 period.

788 Even though Italy's response indicates that most of the provisions of Seveso II Directive have
789 been implemented and that the overall Italian framework was consistent with the Directive,
790 some critical issues regarding the possibility of systematic evaluation by the Authorities of all
791 the management and technical aspects in the safety reports before formal authorization
792 (connected to the institution of sworn safety report by a technical expert) were raised by EC
793 that referred Italy by the Court of Justice. Additionally, some key aspects of the Directive
794 implementations were verified, such as low levels of testing of external emergency plans and
795 inspections, with only 20% of higher-tier establishments being inspected throughout the
796 period and none being inspected once a year. On the other side, while Seveso II does not

797 concern *“the transport of dangerous substances and directly related intermediate temporary*
798 *storage by road, rail, internal waterways, sea or air, outside the establishments covered by*
799 *this Directive, including loading and unloading and transport to and from another means of*
800 *transport at docks, wharves, or marshalling yards”*, the Italian transposition by D.M.
801 293/2001 was more conservative, as it explicitly foresaw a safety report known as RISP (Port
802 Safety Integrated Report) also for industrial harbour areas.

803 Spain response indicates that the majority of the provisions of the Seveso II Directive are
804 implemented. Nevertheless, the level of external emergency plans testing is low, with more
805 than half of the plans have not been tested during the reporting period and a large number of
806 upper-tier establishments were not inspected annually or during the reporting period.

807 In this latest evaluation of the implementation of EU Seveso II Directive, the EU Council
808 classified the overall status of implementation on three levels: fully implemented, almost full
809 implementation and implementation gaps (Calero, 2017). France, Germany and Spain are in
810 the almost full implementation category. It is important to highlight that this middle category
811 is a range with minor implementation issues identified (e.g. only a few external emergencies
812 plans not tested) and some with potentially more serious issues. In the quoted study, only Italy
813 is considered to have more substantial implementation gaps.

814 Despite this overall acceptable implementation, the real impact of the correct application of
815 the EU Seveso Directives remains problematic, mainly due to the limitations of the current
816 monitoring system. Aware of this observation, the European Council has tried to develop
817 indicators and metrics to try to improve the evaluation of the EU Seveso III Directive
818 (Cherrier, 2019). The need was to identify the limitations of the actual used monitoring
819 system on the risk levels. The final objective was to propose a new reporting template for the
820 Member States including safety indicators. A review of the detailed metrics was reported. The
821 simplest example of the implementation questionnaire is the examination of the evolution of

822 the total number of Seveso establishments. Table 5 summarises four proposed indicators,
823 three of which are normalised for the four Member States concerned (Calero, 2017).

824 *Table 5 – Some potential values of the total number of Seveso establishments (year 2004).*

825 A high value in the number of Seveso establishments, as in Germany for example, might
826 reflect growth in terms of increased industrial activities or an expanding economy. But it can
827 also be due to better compliance of the Directive among establishments or even related to
828 changes in classification system for Seveso establishments (i.e. through the link to the Global
829 Harmonised System of Classification and Labelling of chemical substances). The normalised
830 metrics, such as the total number of Seveso establishments per million inhabitants or 1,000
831 km² or unit GDP, can be useful in drawing comparison between the countries, but care must
832 be taken while interpreting the results. For example, the total number of Seveso
833 establishments per million inhabitants indicate globally where people are most exposed to
834 risk, but this indicator does not distinguish areas at risk to the population. In the same way, a
835 Member State with a low GDP, as for example Spain, can be ranked higher in terms of
836 establishments per GDP when compared to a country with a higher GDP as France, even if
837 the latter country has significantly higher numbers of establishments compared to the former.
838 Finally, it would appear that there is a consensus to retain the indicator of the total number of
839 Seveso establishments per million inhabitants.

840

841 5.3 - National implementation of the EU Seveso III directive

842 For the EU Directive Seveso III, the first reporting period should cover the period between 1
843 June 2015, date at which the Directive becomes fully applicable in the Member States, and 31
844 December 2018, to allow Member States the time necessary to assess the information
845 collected and submit it to the Commission by 30 September 2019. The subsequent four-yearly
846 reporting periods will cover the periods between 1 January of the first year of the reporting

847 period and 31 December of the fourth year of the reporting period. As a result, it is too early
848 at the moment to have comparative data for the implementation of the all the articles present
849 in the EU Seveso III Directive.

850 It is worth highlighting that in Italy Seveso III Directive 2012/18/EU was fully implemented
851 by the Legislative Decree 105/2015, specifying the template for a list of safety deliverables
852 and representing a well thought out and documented framework. In fact, the Decree is
853 completely structured along with all technical requirements, guidelines and rules for the
854 actual implementations of the Directive provisions, as specified into 17 annexes (labelled 1 to
855 6 foreseen by the Directive and A to M specifically envisaged by the Italian implementation).
856 These last ones allow obtaining a consolidated single text, without the need of waiting
857 subsequent enforcement and implementing Decrees, such as those foreseen in D. Legs. n.
858 334/1999 that in several cases were not drawn up. Notably, the enforcement of the new
859 Directive amended from the field of application the previously mentioned Port Safety
860 Integrated Report, a simplified port safety analysis only envisaged by the Italian legislation.

861

862 5.4 – Examples of some variations in implementation

863 The previous sections showed that the practice of implementing the Seveso Directives was
864 most often the result of a dichotomous assessment between compliant and non-compliant, as
865 Bondarouk and Mastebroek (2018) pointed out. This is why this section describes some
866 selected examples showing the significant variability in the application of the implementation
867 of the obligations of the Directives in the respective areas of LUP approaches and criteria,
868 LUP case studies and domino effects.

869 5.4.1 – LUP approaches and criteria

870 Articles 12 and 13 of the EU Seveso II and III Directives respectively define the obligations
871 of the Member States concerning Land Use Planning requirements. The management of the
872 distances or zones of effect in the LUPs between a Seveso industrial establishment and
873 territorial establishments, such as individual houses, collective buildings, public buildings
874 (hospital schools), offices block... presents an important societal and environmental
875 requirement.

876 Feedback from the analysis of the scientific literature shows the diversity of approaches,
877 procedures and criteria applied in the European Union, despite the publication of official
878 guides and tools to assist in the effective implementation of the LUP (Basta et al., 2008 -
879 Christou and Porter, 1999 – Christou et al., 2006 – UNECE, 2017 – Rasmussen et al., 1999).

880 In fact, the current European situations regarding LUP is quite jeopardized as shown in Fig. 1
881 where methodologies are divided into the following categories: deterministic approaches with
882 implicit judgment of risk; consequence-based approaches; risk-based or “probabilistic”
883 approaches; semi-quantitative approaches.

884 *Fig. 1 - Overview of different approaches to LUP in the different European Countries.*

885

886 Salvi and Gaston (2002), Cahen (2006), Merad et al. (2008), Merad and Dechy (2010),
887 Taveau (2010) and Nicolas (2019) reported on the synthesis of the LUP approach applied in
888 France. Walker (1991), Walker (1995) and Hauptmanns (2005) discussed Land Use Planning
889 for process plants, while KAS 18 (2010), the short English version KAS 18F (2010) and KAS
890 32 (2015) detail the recommendations for the separation distances of various scenarios for
891 LUP implementation in Germany. Carpignano et al (2001), Cozzani et al (2006), Manca and
892 Caragliano (2007), Demichela et al (2014) and Pilone et al (2018) described, among other
893 things, the mandatory use of the technical document "Rischio di Incidente Relevante" (RIR)
894 for the Italian LUP procedures. Riera et al (1991), Casal and Vilchez (2010), Ponce (2013)

895 and Suffo et al (2015) published contributions concerning the LUP application in Spain. More
896 general papers for local planning regulations contain also a review of the LUP criteria
897 (Christou et al. 1999, Christou and Porter, 1999, Christou and Matarelli, 2000, Christou et al,
898 2011, Gyenes et al. 2017).

899 Table 6, modified from the general table published by Christou et al (1999), presents the LUP
900 practices for the four Member States concerned. It is possible distinguishing four
901 methodological approaches:

- 902 - establishing generic distances, mainly based on experience and the environmental
903 impact of industrial activities,
- 904 - the based consequence approach,
- 905 - the based risk approach,
- 906 - arrangements still in the development phase.

907 *Table 6 – Brief overview of the LUP practices in 1999 (adapted from Christou et al., 1999).*

908 Germany used mainly the approach of generic separation derived from expert judgements.
909 The consequence-based approach focuses on the assessment of the consequences of a number
910 of reference scenarios. This method has generally been used in France, Germany and Spain.
911 In the year 1999 Italy and Spain were still in progress to prepare arrangements.

912 However, the evolution of the implementation of approaches over time must be highlighted.

913 Table 7 updates the situation for the year 2004 (Basta and Struckl, 2004)

914

915 *Table 7 – Hazard/risk assessment methods used in LUP (reference year 2004) (adapted from*
916 *Basta and Struckl, 2004).*

917 The risk-based approach (or probabilistic approach) is based on the assessment of both the
918 consequences and probabilities of all scenarios (full) or pre-selected scenarios, as is the case

919 for Galicia (full) and Catalonia (probabilistic plus a safety strip defined by preselected
920 scenarios) and Germany (preselected) respectively. France has further evolved with the new
921 LUP law (2003) following the Toulouse major accident by introducing sequential classes of
922 probabilistic assessment.

923 Kirchsteiger (1999) has discussed the respective strengths and weaknesses of the two main
924 deterministic and probabilistic approaches of risk analysis in the chemical process industries.
925 At this stage, considering the two approaches applied by the four Member States concerned, it
926 is possible to conclude that, for a given establishment or installation, the based consequence
927 approach evaluates the distances or consequence areas of lethal effects and severe injuries for
928 the scenarios considered. On the other hand, the risk-based approach defines areas identified
929 by probabilities of different severity levels for the scenarios selected.

930 As already remarked, the transposition of Seveso II European Directive into the Italian
931 legislation was attained by means of the 334/1999 Legislative Decree set into force on
932 October 1999, where the 14th article foresaw the adoption of minimum safety requirements for
933 land use planning around major risk establishments. Quantitative LUP criteria were
934 subsequently envisaged by the Ministerial Decree 9 May 2001. (Ministerial Decree
935 09/05/2001 on the minimum requirements for land- planning and urban-planning in areas in
936 the vicinity of major risks installations), as summarized in Table 8.

937 *Table 8 - Territorial categories and Italian urban planning.*

938 The schematic flow sheet shown in Fig. 2 evidences the logic steps for the semi-quantitative
939 criterion.

940 *Fig. 2 - Schematic flow sheet for the semi quantitative approach to land use compatibility.*

941

942 In this regard, it should be noted that a number of critical issues regarding Italian LUP are
943 still unresolved, e.g.:

- 944 - the majority of Municipalities has not yet adapted urban planning tools in terms of
945 RIR (major accident risk);
- 946 - the actual definitions of “Existing building index” (ex-Environment Ministry Decrees
947 DMA 15/5/1996 and 20/10/1998) and “Building land index” (ex D.M. LL.PP.
948 09/05/2001);
- 949 - harmonization of the methodologies for the evaluation of land use compatibility DMA
950 15/5/1996 and 20/10/1998 (storage class vs. effect categories) and D.M. LL.PP.
951 09/05/2001 (frequency vs. effect categories);
- 952 - the need of coordination with the Environment Reference Text EIA/SEA (Directive
953 18/2012 art. 13, c. 4).

954 An important additional difference contributes to the variation in the implementation of the
955 LUP between Member States according to the levels qualifying the human health damage
956 generated by the danger phenomena encountered. Table 9 compares the levels of human
957 health damage in the four Member States. The first line of the table defined a 6-level generic
958 ranking associated with the effects on human targets. Despite the uncertainties, the rest of the
959 table shows the indicative danger zones adopted by each country.

960 *Table 9 – Correspondence between generic level of human health damage and level of harm*
961 *selected by the four Member States (adapted from Cherrier, 2014).*

962 In practice, the distances delimiting hazard zones are based on threshold values (or endpoints)
963 depending on the intensity of the hazardous phenomena. Tables 10 and 11 present the
964 numerical limit values characterizing the effects of pressure wave overpressure and thermal
965 radiation. The values adopted by France and Italy for overpressure appear to be the most
966 restrictive of those reported in the table 10 for levels 3 and 4. On the other hand, for thermal
967 radiation, the threshold values are quite similar in the table 11

968 *Table 10 – Overview of thresholds for overpressure (mbar) (adapted from Cherrier, 2014 and*
969 *KAS 18, 2010).*

970 *Table 11 – Overview of thresholds for thermal radiation (Kw/m²) (adapted from Cherrier,*
971 *2014 and KAS 18, 2010).*

972 The situation is even more complex when trying to select toxicity thresholds for assessing the
973 consequences of the dispersion of a toxic cloud. For example, Cherrier (2014) compiled the
974 different toxicological criteria used during an accidental event. Table 12 lists these values for
975 the four countries concerned.

976 *Table 12 – Overview of toxic criteria (adapted from Cherrier, 2014).*

977 ¹In Spain, even if the references names have been always kept in the same way, the criteria behind changed between the first
978 (1991) and the second (2003) Basic Directives. For instance, in terms of assessment of toxic effects, the first Basic Directive
979 considered the IDLH as reference to define the Intervention Zone and there was no specific criteria defined for the alert zone,
980 even if considered. Whereas in the second Basic Directive, the Alert Zone was defined, in order of priority, as the AEGL-1,
981 ERPG-1 and/or TEEL-1 and the Intervention Zone as the AEGL-2, ERPG-2 and/or TEEL-2, as well in this order of priority.

982 5.4.2 – Examples of LUP case studies

983 As examples, the potential impact of the diversity of these risk assessment approaches and
984 selected threshold values can be illustrated by three LUP case-studies.

985 Example 1 – The LPG depot case study

986 The first one refers to loading and unloading from an LPG depot. The bench marking exercise
987 was implemented by 8 participants from 8 different EU member states, including France, Italy
988 and Spain. Details of the conditions examined are given in the reference (Gyenes et al, 2017).

989 The objective was to illustrate the nature of the results obtained, on the basis of identical pre-
990 selected scenarios, according to the procedures for assessing potential damage and the
991 subsequent decisions authorizing or not urban development around LPG's industrial site. Fig.

992 3 shows a simplified view of the position of the hazard source and potential targets for urban
993 location.

994 *Fig. 3 – Schematic map of LUP development around the LPG establishment.*

995

996 Table 13 summarizes the decisions of participants P1 to P8 resulting from the damage
997 assessment on targets in future development projects. Obtained results varied only slight in
998 regard to LPG facility. All but 2 countries prohibited development within 200 m of the plant.
999 Conversely 7 out the 8 partners permitted development at 300 m and beyond. At 600 m every
1000 country allowed development.

1001 *Table 13 – LUP decisions based on the LPG facility analyses (adapted from Gyenes et al.*
1002 *2017).*

1003 This simple example should not obscure the fact that there may still be, even in the case of an
1004 identical scenario, conditions of variability that may lead to different consequences depending
1005 on the distances to the source of danger.

1006 Example 2 – Chlorine and anhydrous ammonia leaks on an storage tank

1007 This example provides the consequences of different LOC (Loss of Containment) accident
1008 scenarios with two reference selected substances, chlorine and ammonia, commonly used in
1009 industrial processes. The representative numerical threshold values for toxicity criteria
1010 adopted by each country for ammonia and chlorine are extracted from the toxicological data
1011 tables (Withers and Less,1985-Protectione Civile,1994-DGPC, 2003-Tissot et al., 2003-VDI,
1012 2006-NIOSH, 2007-EPA, 2019 and INERIS, 2019). They differ significantly and are often
1013 difficult to compare. As the probabilistic quantitative approach is more and more favoured, it
1014 is recommended to use threshold values associated with their corresponding functions of
1015 Probit (RIVM, 2017 and RIVM, 2018).

1016 Fig. 4 therefore illustrates, in the case of a guillotine breakage of a valve located at the bottom
1017 of a spherical liquid chlorine storage tank, the influence of the choice of thresholds on the
1018 plume effect distances.

1019 *Fig. 4 - Concentration of chlorine versus distance from a scenario considering the guillotine*
1020 *breakage of a valve at the bottom of a spherical liquified chlorine storage tank.*

1021 Pey et al. (2009) reported similar results in the case of an ammonia leak.

1022 Fig. 5 shows the consequences in terms of distance planning the results that would be
1023 obtained in the scenario of leakage in 1 minute of the whole inventory of a tank containing
1024 circa 3 m³ of liquefied ammonia.

1025 *Fig. 5 - Distances of concern for ammonia in case of a scenario defined in a vessel of 3 m³*
1026 *releasing its inventory in 1 minute (Pey et al., 2009).*

1027 Distances, together in case of both chlorine and ammonia, show how it is possible that
1028 planning distances for external emergency response lead to a situation where, for the same
1029 scenario, the longest distances in some countries are shorter than the shortest distances in
1030 another country.

1031 Amendola et al. (1992), Christou et al. (1999) and Gyenes et al. (2017) showed in
1032 benchmarking exercises the uncertainties generated by the choice of threshold values during
1033 the same scenario studied simultaneously by several teams of stakeholders. Well aware of
1034 these difficulties, the European Council initiated and supported the Acutex project within the
1035 framework of the EU Seveso II Directive. The project aims at the development of a European
1036 methodology for producing Acute Exposure Threshold levels (AETLs) for the toxic
1037 substances to be applied in major hazard control and in particular emergency response and
1038 Land Use Planning. The report was published in 2006 in the form of a Technical Guidance
1039 Technique accompanied by software, application and validation exercises (Acutex, 2006).

1040 However, these results were not followed up because no regulatory values were proposed at
1041 the European level.

1042 Example 3 - Gas treatment and compression systems for naturel gas

1043 At last, in the following we provide an original worked example concerning a natural gas
1044 compression plant consisting of four lines with centrifugal compressors and gas turbine,
1045 provided with basic control system and with Emergency Shutdown System (ESD) safety
1046 system. Auxiliary sections include H₂S treatment plant, fuel gas skid, nitrogen generation
1047 package, diesel storage tank and emergency diesel generator package (Contini, 2010). A
1048 number of vulnerable targets were identified in the surroundings of the establishment while
1049 the railway runs along the direction NNW at a minimum distance of 780 m. In a south-south-
1050 westerly direction the area is totally rural, while the closer residential areas are nearly 300 m
1051 from the plant fence line.

1052 The worst scenarios considered separately for the different plant sections can be summarized
1053 as follows: horizontal and vertical jet fires; vapour cloud explosion; H₂S dispersion due to 50
1054 mm, 100 mm and full rupture of the pipework. Following weather conditions were considered
1055 with reference to Pasquill stability class: F, wind speed 1.5 m/s; D, wind speed 1.5 m/s; D,
1056 wind speed 5 m/s. Fig. 6 provides the results of the individual risk calculated in the given
1057 area for the accident scenarios identified above.

1058 *Fig. 6 - Individual risk map (1/year) considering all accident scenarios in the given area with*
1059 *vulnerable targets (Contini, 2010).*

1060

1061 It stands to reason that accident scenarios not extending beyond the plant limits can be
1062 neglected for LUP purposes (e.g. diesel storage tank and emergency group pipework).
1063 Threshold values were chosen according to the Italian approach as follows: overpressure 140
1064 mbar, stationary heat radiation 7 kW/m², flash-fire envelope concentration LFL/2. Severity

1065 ranking for the French LUP approach was evaluated utilizing threshold criteria and number of
1066 people potentially exposed, according to the criteria summarized in Tables 10 – 11- 12 and 14
1067 respectively.

1068 *Table 14 - Range of number of people exposed to hazard for severity assessment in France.*

1069

1070 The damage categories for physical effects –Elevated Lethality, Start of Lethality, Irreversible
1071 Damage and Reversible Damage and occurrence probability levels of probability are
1072 evaluated according to the Italian criteria by the matrix shown in Table 15 and evidencing the
1073 compatibility with the specific territorial categories summarized in the previously mentioned
1074 Table 8. Analogously, the compatibility MMR matrix (Mesures de Maîtrise des Risques, i.e.:
1075 “measures of risk control”) summarized in Table 16 was utilized for ranking the scenarios that
1076 are subjected to the PPRT (Plans de Prévention des Risques Technologiques), i.e.
1077 Technological Risks Prevention Plans.

1078 *Table 15 - Land use compatibility matrix: physical effects vs. probability class for Seveso*
1079 *establishments in Italy.*

1080 *Table 16 - Evaluation matrix for Land Use Planning in France.*

1081

1082 To the purpose of this paper, results of the worked example are presented in visual form of
1083 immediate readability in Figs. 7 and 8 respectively resulting from the application of the Italian
1084 and French criterion.

1085 *Fig. 7 – Land Use Planning in the given area according to the Italian criterion (Contini,*
1086 *2010).*

1087 *Fig. 8 - Land Use Planning in the given area according to the French criterion (Contini,*
1088 *2010).*

1089

1090 The LUP measures needed for the areas beyond the plant boundaries and respect zone
1091 depends upon local LUP legislation. As summarized in Table 17, it is noteworthy noting that
1092 the two national LUP criteria allow attaining controversial decisions regarding the territorial
1093 compatibility of existing vulnerable targets.

1094 *Table 17 - LUP compatibility of existing, or planned vulnerable targets in the given industrial*
1095 *area, according to Italian and French criteria (Contini, 2010).*

1096

1097 Additionally, French legislation strictly excludes the possibility of new residential buildings at
1098 distances lower than 370 m from the establishment fence line while existing buildings at a
1099 distance lower than 300 m must be expropriated or ceased. The outcomes of this case study
1100 evidences as well some challenges, for example the need of ensuring for LUP purpose also a
1101 proper evaluation of environmental effects and consequences of a possible process accidents,
1102 currently not explicitly considered in the legislative frameworks.

1103

1104 5.4.3 – Domino effects

1105 Since the EU Seveso I Directive was published in 1982, the European Commission has
1106 implicitly recognized the notion of a domino effect. Indeed, the recommendations of Articles
1107 5 and 7 and the Annexes are indicated in order to avoid the risks of aggravation of major
1108 accidents in inside and outside installations less than 500 meter apart for certain substances or
1109 groups of substances in establishments or groups of establishments.

1110 Since then articles 8 of the EU Seveso II Directive and 9 of the EU Seveso III Directive
1111 explicitly mention the need to take the domino effect into account in the assessment of major
1112 accident risks.

1113 Therefore, the European Commission asks Member States to report on the implementation of
1114 the EU Seveso Directives. This report must be drawn up on the basis of a predefined

1115 questionnaire. The questions concerning domino effects are reported in the corresponding
1116 appendices of the Directives. For example, for the part of the report concerning the domino
1117 effect and covering the period of the last three years, the answers to the mandatory and
1118 optional items should be collected in a predefined template (Reniers and Cozzani, 2013).

1119 For the four States examined in this article, here is an extract from the results of the EU
1120 17082/i2 report of 12 May 2017 on the implementation of the domino effect in the Seveso II
1121 Directive (Calero, 2017).

1122 France

1123 The identification of domino effect risks is achieved mainly through inspections, based on the
1124 inspectors' knowledge of the establishments and their environment. Communication between
1125 neighbouring establishments is required by a ministerial decree from 2000, which specifies
1126 that any relevant information on the risks and hazards of major accidents has to be submitted
1127 by the operators to the neighbouring establishments and the authorities. This information is
1128 also included in the permits issued by the regional prefectures and in internal emergency
1129 plans. In addition, operators communicate through meetings and correspondence and in the
1130 framework of site monitoring committees and permanent secretariats for the prevention of
1131 industrial pollution. Operators can cooperate on alert systems, intervention measures,
1132 informing the public and testing of external and internal emergency plans.

1133

1134 Germany

1135 Groups of establishments posing a risk of domino effects are identified by the relevant
1136 authorities in two steps in Germany:

1137 a) - All upper-tier establishments not further than 500 m away or lower-tier establishments
1138 200m away from any installations or activities of another establishment, as well as

1139 establishments where there are any specific indications of a risk of domino effects are taken
1140 forward for step b.

1141 b) - On a case-by-case basis, additional information is analyzed such as location and
1142 environment of the establishment, specific risks from activities and installations of the
1143 establishment and the hazardous substances present.

1144 When a risk of domino effects is identified, safety concepts, safety management systems,
1145 safety reports and internal emergency plans are exchanged between the affected
1146 establishments to establish a common risk management approach. Regular safety meetings
1147 and joint exercises are held. The exchange of information is coordinated by the major
1148 accidents officers of the establishments, or a common officer is established. Some
1149 establishments prepare a common emergency plan or coordinate their plans. Some plans also
1150 include a common alarm center, or in the case of industrial areas with a high density of
1151 establishments working groups on factory manager level. Compliance is checked and
1152 supported by the relevant authorities and reviewed in inspections.

1153

1154 Italy

1155 The Ministry of Environment identifies groups of establishments which are potentially subject
1156 to “domino effects” using the information provided by the Competent Authorities in each
1157 region. These Regional Authorities have the opportunity of assessing this in two instances:
1158 evaluation of safety reports (every 5 years), or for assessments related to changes at
1159 establishments that are deemed to increase the level of risk. The Ministry ensures that
1160 Regional Competent Authorities have all the necessary information to enforce measures to
1161 prevent domino effects in these establishments, such as facilitating information exchange,
1162 drafting contingency plans or conducting integrated safety studies.

1163

1164 Spain

1165 Establishments relevant for consideration of domino effects are identified by the competent
1166 authority in each Regional Government, based on information from the establishments' safety
1167 reports and on criteria established in the Spanish legislation. They communicate this to the
1168 Central Government and establishments in question.

1169 These establishments are required to exchange information on the effects of accidents and
1170 information on emergency plans. Also, the Regional Governments have promoted the creation
1171 of committees among operators involved in domino effects, in order to encourage information
1172 exchange and participation in joint exercises.

1173

1174 It should be noted that the comparison of the implementation of the domino effect in the four
1175 Member States is not easy, as the content of the replies is not very exhaustive. Indeed, the
1176 wording of the items in the question concerning the article on the domino effect of the
1177 questionnaire sent to Member States has evolved over time and is too simple or even
1178 simplistic. For example, it is not possible in the analysis of the responses to the Member
1179 States reports to determine the methodology used to identify the targeted establishments or
1180 groups of establishments. Similarly, the possibility, or probability or consequences of a major
1181 accident caused by a domino effect are not specified. However, recent significant advances in
1182 scientific and technical knowledges of the domino effect (Reniers and Cozzani, 2013;
1183 Sandoval et al., 2019) could now have improved the content of the questionnaire. The
1184 presence of an impact map visualizing domino effects, for example, would be interesting.
1185 Unfortunately, the questionnaire has not been updated on this point for the next evaluation
1186 report on the implementation of the EU Seveso III Directive

1187

1188 **6 – Control and inspection practices in the States**

1189 The Commission has two tasks concerning the control of implementation of EU Community
1190 Law in the Member States. On the one hand, it must verify that EU Community Directives are
1191 correctly and integrally implemented in national laws, regulations and administrative
1192 provisions. On the other hand, it must control that the appointed provisions are concretely
1193 implemented by practice.

1194 Article 18 of the EU Seveso II Directive requires Member States to ensure that their
1195 competent authorities organize an inspection system or other control measures appropriate to
1196 the type of establishment concerned, such as upper tier Seveso establishments, for example.
1197 This inspection requirement is confirmed and reinforced in Article 20 of the EU Seveso III
1198 Directive. The potential for practical application of the implementation of the inspection
1199 content of these two directives is the best tool for the EU Council to ensure their effective
1200 overall enforcement. In the absence of a team of European inspectors, each Member State is
1201 itself responsible for organizing good enforcement practices. However, each inspection plan
1202 shall include at least the following elements: a general assessment of the relevant safety
1203 issues, the geographical area covered by the inspection plan, a list of establishments covered
1204 by the plan, a list of groups of establishments likely to have domino effects, a list of
1205 establishments where particular external risks or sources of danger could increase the risk or
1206 consequences of a major accident, procedures for regular inspections, including programmes
1207 for such inspections, procedures for non-regular inspections and if applicable the provisions
1208 on cooperation between different control authorities. Some different guides are also
1209 specifically proposed to provide the minimum criteria for the inspection required by article 18
1210 (Papadakis and Porter, 1999 - OJEC, 2001). Let us now look at the different ways used by the
1211 four Member States concerned.

1212 6.1 - Seveso inspections in France

1213 In France, historically, the services of inspection of classified installations (ICPE), defined by
1214 the imperial decree of 15 October 1870, were governed by the labour inspectorate. In the late
1215 1960s, the inspection of classified installations was entrusted to the mining services, then
1216 transferred in 1971 to the Ministry of the Environment when it was created.

1217 Today within the Ministry of Ecological and Solidarity Transition (2019), the General
1218 Directorate for Risk Prevention (DGPR) establishes the regulations, checks their application
1219 and coordinates the local inspection services. Under the authority of the "département"
1220 prefect, the inspectorate's tasks are performed by the DREAL (Regional Directorate for the
1221 Environment, Development and Housing). The inspectors of the DREAL are state certified
1222 agents. Inspectors from DREAL classified installations are mainly recruited through a
1223 national competition based on qualifications upon graduation from mining engineering
1224 schools (master level of environment or process safety). Inspectors comply with the
1225 inspection charter for classified facilities by sharing the unifying values of competence,
1226 impartiality, fairness and transparency.

1227 It is difficult to estimate the order of magnitude of the ratio "one inspector DREAL / n Seveso
1228 establishments". In 2018, the inspection of classified installations had around 1,300 DREAL
1229 inspectors to control 25,000 establishments subject to authorization, including 1,312 Seveso
1230 establishments (upper and lower tier). According to Marcellis-Warin et al., 2003, about 10-15
1231 % of DREAL inspectors would only deal with Seveso establishments, i.e. about 150
1232 inspectors for 1,312 sites. The order of magnitude of the ratio would therefore be "one
1233 inspector for 9 Seveso sites.

1234 The French inspectorate's action is organised around three areas and includes the principle of
1235 proportionality to the issues:

1236 - Regulation: processing activity authorisation, registration, modification and cessation
1237 request files, proposing to the prefects the operating requirements for the site and

1238 updating these requirements in accordance with technical developments and
1239 environmental protection requirements;

1240 - Inspection of classified facilities: carrying out scheduled and unannounced
1241 inspections, examining studies and assessments, and proposing administrative
1242 sanctions to the prefect and criminal prosecutions to the public prosecutor in the event
1243 of violation;

1244 - Provision of information to the public and operators.

1245 In all cases, an inspection visit is a visit by two at minimum or more inspectors to the
1246 establishment site to verify compliance with the laws and regulations relating to classified
1247 facilities. The controls can be:

1248 - Announced - they are the subject of a prior information letter to the operator at least
1249 48 hours in advance;

1250 - Unannounced - the inspector arrives at the entrance of the company, without prior
1251 notification to the operator.

1252 In order to adapt the inspection to the challenges of the site, the inspection can be classified
1253 according to the purpose of the visit:

1254 - Targeted - the purpose of the inspection is to analyse one or more parameters or
1255 workshops of the classified installation;

1256 - General - the inspection will cover all operating conditions and compliance with
1257 requirements of the prefect.

1258 In the same way, depending on the level of detail of the control, the inspection may be:

1259 - in-depth: this is a site control requiring detailed preparation;

1260 - current - this type of site control does not require heavy preparation but only normal
1261 knowledge of the site by the inspector (installations, administrative context, findings
1262 of previous inspections...);

1263 - punctual (also called rapid) - this is a site control that is neither a routine inspection
1264 visit nor an in-depth inspection visit. A spot inspection visit covers only a limited and
1265 targeted number of checks.

1266 Lastly with a classification according to the control nature, the control can be:

- 1267 - planned - they are programmed as part of an annual or multi-year planning process,
1268 based on national priorities and regional issues;
- 1269 - circumstantial - they were not subject to prior planning as part of the inspection
1270 programme and were initiated by an event that was difficult to predict (complaint,
1271 request of third parties, followed by a formal notice, accident, cessation of activity,
1272 etc.).

1273 Generally, an inspection visit is divided into:

- 1274 - an opening meeting, which allows the inspector to identify the interlocutors present, to
1275 announce or recall the topics planned for the inspection, or even to identify the
1276 documents to be sought during the visit;
- 1277 - on-site, indoor and facility monitoring of operating conditions and regulatory
1278 compliance, with support from a representative of the operator;
- 1279 - a closing meeting at which the operator may provide additional information and the
1280 inspector shall explain the non-conformities identified and the action he intends to
1281 take.

1282 The length of these different phases is adapted to the size of the company and the challenges.

1283 The visit is the subject of a follow-up letter summarizing the inspector's main conclusions.

1284 This letter is sent either by the prefecture or by the service responsible for inspection. The

1285 visit is also the subject of an inspector's report. This report allows the inspection to keep a

1286 record of the operation of the installation; it also allows the inspector to discuss with his

1287 superiors and the prefecture any follow-up to be given to the visit.

1288 An inspection lasts on average 4 days including preparation, site visit and reporting (
1289 Marcellis-Warin et al., 2003). Establishments do not pay for inspections carried out by
1290 DREAL. For inspections of Seveso upper tier establishments, DREAL almost systematically
1291 calls on a third part expert, the cost of which is at the operator's expense.

1292 Each year the inspection of classified installations defines a national strategic control
1293 programme by themes. The inspection programme provides for minimum inspection
1294 frequencies of at least once a year for upper tier establishments and at least once every three
1295 years for lower tier establishments.

1296 For example, in 2013, for the Alsace region, with 29 upper tier establishments respectively,
1297 92 inspection visits were carried out and with 16 lower tier establishments 25 inspections
1298 were carried out (DREAL, 2013). At the national level, the part inspection of the final report
1299 submitted by France to the EU Council for the 2012-2014 period states that inspections were
1300 carried out at least once for 100% of upper-tier sites and 98% of lower-tier sites. Annual
1301 inspections were held in 611 establishments representing 96% of total upper tier
1302 establishments. The fact that 4% of upper tier establishments were not inspected annually is
1303 highlighted as an aspect of the implementation of the Directive that may warrant further
1304 investigations (Calero, 2017).

1305 It should be mentioned that an instruction, from the Directorate of Labour Relations (DRT) of
1306 the Ministry of Employment and Solidarity of 14 April 2006 on enhanced collaboration
1307 between the inspections in charge of the control of establishments classified as "upper tier
1308 Seveso", strongly encourages the purpose and modalities of collaboration between labour
1309 inspection and inspection of classified installations through reciprocal joint training, incident
1310 and accident management, joint site visits and periodic meetings (BO, 2006).

1311

1312 In France, on September 26, 2019, at Lubrizol's ICPE Seveso upper tier facility in Rouen, the
1313 major fire in a flammable product storage facility has rekindled the societal concern of people
1314 living near dangerous industrial sites and raised questions about the effectiveness and
1315 transparency of the inspection of Seveso sites. Although France also generally meets the
1316 periodicity of inspections (one on-site inspection per year for upper tier and one on-site every
1317 three years for lower tier) required by the EU Seveso Directives, there has nevertheless been a
1318 significant decline in the protection of the environment and populations. For example, in
1319 2009, French legislation created the registration regime located between authorisation (Seveso
1320 sites) and declaration (less dangerous sites). An establishment under the registration regime is
1321 no longer systematically subject to an environmental impact assessment. Since Order 2017-80
1322 of 26 January 2017, then Decree 2018- 435 of 04 June 2018, Seveso establishments subject to
1323 authorisation are no longer required to carry out an impact study either, except on a case-by-
1324 case basis. These examples of simplification are intended, according to the supervisory
1325 authority, to reduce certain procedural measures, which mobilized the inspection of ICPE at
1326 the expense of inspection controls. However, between 2016 and 2018 the number of DREAL
1327 inspectors decreased slightly from 1627 to 1607. However, it is difficult to assess the impact
1328 of this decrease on the Seveso sites concerned, as the overall number of inspections has also
1329 decreased.

1330 6.2 - Seveso inspections in Germany

1331 The Federal Republic of Germany is based on the federative principle and so the competences
1332 and responsibilities for legislation as well as the administrative and control activities are
1333 divided between the federal state and the countries (16 countries as members of the
1334 federation). The competences and responsibilities are well defined. Federation and Countries
1335 work together. All countries are independent (independent from the other countries and
1336 independent from the federal state) in realizing their allocated responsibilities. However, to

1337 ensure reconciled and concerted administration activities over the countries (Länder) they
1338 established federal coordination committees. For questions of immission control and process
1339 and occupational safety these committees are:

1340 - The LAI (Länderausschuss für Immissionsschutz) – Federal Committee for Immission
1341 Control) and

1342 - The LASI (Länderausschuss für Arbeitsschutz und Sicherheitstechnik) – Federal Committee
1343 for occupational and technical safety.

1344 Regarding the implementation of the Seveso directive, the federal state is responsible for
1345 establishing respectively updating the necessary legal framework, maintaining databases for
1346 Seveso establishments and reported major accidents and giving reports to the European
1347 Commission.

1348 The authorities for the administrative and practical execution of the statutory provisions of the
1349 directive (respectively the German Major Accident Ordinance) and the approval procedure for
1350 Installations subject to approval are established in the countries. Here usually upper and lower
1351 countries' authorities are assigned with the duties of the competent authorities compliant with
1352 the Seveso directive (respectively the Major Accident Ordinance).

1353 Responsible and authorized for administrative measures and practically conducting the
1354 inspections of Seveso establishments are usually the trade supervisory authorities (with
1355 specific sections for occupational safety and immission control) or state departments for
1356 environment or environmental protection and occupational safety. As specialist authorities
1357 they also play an important role in the approval procedures for installations.

1358 Concerning this matter and for easing and harmonization of the administrative actions the
1359 immission control and occupational safety authorities have issued a collective guide for the

1360 supervision system according to § 16 Major Accident Ordinance (corresponding with Art. 18
1361 Seveso directive) via their cross-border established federal coordination committees LAI
1362 (Länderausschuss für Immissionsschutz – Federal Committee for Immission Control) and
1363 LASI (Länderausschuss für Arbeitsschutz und Sicherheitstechnik – Federal Committee for
1364 occupational and technical safety). This guide serves as an orientating frame for conducting
1365 the inspections.

1366 The inspection-related activities are divided in three steps:

1367 a) Determination of the inspection intervals – setting of priorities

1368 b) Preparation and execution of the inspections

1369 c) Post-processing

1370 In several cases the single responsible authorities have described and published their approach
1371 and applied procedures for inspections. Some responsible authorities have made their
1372 arrangements on Seveso inspections via agreements on objectives. For conducting the
1373 inspections comprehensive questionnaires (inspection handbooks) were developed and are in
1374 continual completion. Frequently for the systematic examination of the technical,
1375 organizational and management-related Systems in the companies with Seveso establishments
1376 specifically by the competent authorities developed data processing software is used.

1377 The realization of provisions, as laid down by law, are examined during on-site inspections.

1378 Thereby noticed deficiencies are specified in the inspection report. For the correction of
1379 deficiencies deadlines are set and after remedy reports the follow-up checks are conducted.

1380 For the on-site inspections the results and knowledge from previous inspections naturally are
1381 regarded.

1382 Seveso establishments which, according to their magnitude, can't be inspected in one
1383 inspection event, are examined successively via concerted priority inspections. So normally
1384 after several inspection events the complete Seveso establishment has been inspected.

1385 As a rule, the responsible authorities for environmental protection and occupational safety
1386 have established a coordinated systematic assessment of major accident hazards for the
1387 establishments inside their area of responsibility. On this basis the inspection intervals and
1388 priorities are scheduled. Regarding process safety particularly the following main criteria are
1389 considered in this systematic assessment:

1390 - site resp. production plant related criteria

1391 (Inventory of hazardous substances, Seveso Classification, mode of operation, complexity
1392 and parameters of the process, handling of dangerous substances, standard of process safety
1393 in the establishment, means for the detection of substance releases, object security,
1394 recognitions from known disorders, accidents or major accidents)

1395 - Sensitivity of the local surrounding

1396 (distance to sensitive objects, distance to risk-entailing activities)

1397 - Operator related criteria

1398 (Quality and organization of its own supervision and monitoring system, frequency of
1399 neighboring complaints, previous compliance with permission conditions, result and
1400 valuation of previous inspections, certification per Eco-Management EMAS).

1401 In many cases the on-site inspections occur annually. In one country the upper-tier
1402 establishments are inspected annually and lower-tier establishments are classified, using the
1403 above-mentioned criteria and inspected every 1 to 5 years. As an example, Table 18 shows
1404 the number of annually inspected upper-tier establishments in the single countries
1405 (Bundesland) in Germany during the last reported period of 1st Jan. 2012 until 31st Dec. 2014.

1406 *Table 18 – Number of annually inspected upper-tier Seveso establishments in Germany.*

1407 *Source: Bericht der Bundesrepublik Deutschland gemäß Artikel 19 Absätze 1a und 4 der*
1408 *Richtlinie 96/82/EG des Rates zur Beherrschung der Gefahren bei schweren Unfällen mit*
1409 *gefährlichen Stoffen – Berichtszeitraum: 1.1.2012 bis 31.12.2014*

1410 In another country it was reported, that the inspection system comprises a cycle of maximum
1411 five years, where every Seveso establishment at least once concerning all relevant inspection
1412 issues has to be inspected. This normally comprises multiple on-site inspecting activities.

1413 Usually, the visitation on site and the associated discussions and inquiries utilize ½ to 1
1414 workday. The inspections are conducted subject-matter related and frequently checklists are
1415 applied. According to before defined focal points the operator of the establishment has to
1416 prepare all necessary documents at the time of inspection visits. The inspections are usually
1417 executed by not less than two inspectors. If required by the range of inspected topics
1418 additional specialists of other authorities (e. g. Fire Inspectorate, regional Water authority) are
1419 called in.

1420 The personnel expenditure for inspections – including preparation and prearrangement work
1421 as well as post-processing activities and the related documentation and correspondence – vary
1422 heavily depending on the size and complexity of the inspected establishment. Per inspection
1423 of one single Seveso establishment from the different Authorities time investments between 1
1424 and 12 person-workdays are reported. One country reported for the period of 2009 – 2011 a
1425 total expenditure for all Seveso inspections of 2275 person-workdays.

1426 6.3 - Seveso inspections in Italy

1427 The basic legislative reference for Seveso Inspections is the Environment Ministry Decree
1428 05/11/1997 and art. 25 of Legislative Decree 334/2009. Periodical inspections on the

1429 establishments subjected to the 96/82/CE Directive are performed by an Inspection
1430 Commission composed by three members commonly from Institute for Accident Prevention
1431 and Safety at Work, Italian Ministry of Environment and Protection of Territory or Italian
1432 Ministry of Interior – National Fire Brigade. The results of the first inspections performed
1433 over the time span 1997-2000, even if not satisfying the yearly frequency for upper tier
1434 establishments envisaged by Seveso II Directive, highlighted following challenges:

- 1435 - the increase sensitivity of the Seveso firms towards process safety;
- 1436 - the need of a standardized check-list approach in producing a more consistent
1437 evaluation by the different teams;
- 1438 - the need of developing simplified check-lists for standard activities.

1439 Since the establishments can be at different levels in regard to Seveso requirements and in
1440 regard to overall safety culture development, the first guidelines on Seveso establishment
1441 inspections were released by the Italian competent Authority just one year after the
1442 transposition of Seveso II European Directive. The two-step procedure is based on a
1443 preliminary review pertaining firm's operating experience including near-miss and accident
1444 reporting systems and addressing the subsequent applicative phase of the check-list. The
1445 second step relies on a thoroughly developed and hierarchical framework featuring one
1446 hundred items regarding the Safety Management System and covering eight main topics,
1447 namely Policy, Organization & Personnel, Risk Assessment, Operating Control, Management
1448 of Changes, Emergency Planning, Performances Monitoring & Accident analysis, Control &
1449 Revision. European Commission raised a formal remark as the check list did not include
1450 technical systems assumed to be covered by the standard control programs for pressure
1451 equipment, electrical devices and firefighting systems. As a result, in 2008 a new audit
1452 procedure for Seveso inspections was implemented and subsequently amended in 2009 by the
1453 guidelines provided by the Ministry of Environment and Territory and Sea Protection

1454 (MATTM), with the decree DSA-DEC-0000232 of 25/3/2009. The operator shall provide
1455 inspectors with a written document derived from the Safety report, which allows planning the
1456 objectives and focus of the inspection visit. Considering all scenarios (also very low
1457 probability ones) and identified top-events, it is required to obtain an effective system
1458 overview of the organizational and technical systems for preventing accidents and for
1459 mitigating consequences, or in other words where are present barriers in cause consequence
1460 chains. The preparatory document is intended to allow the inspection team designing control
1461 scheduling and relevant priorities and carrying out the review “planned and systematic”, as
1462 required by the European Directive. On this basis, it is possible outlining a systematic and
1463 structure inspection program per establishment, that provides an overview of all the critical
1464 items to be thoroughly controlled. The control includes effective sample testing of the
1465 “critical components” for prevention/mitigation of accidents, e.g.:

- 1466 - visual inspections of all mechanical components affected by the top events,
- 1467 - sample testing of alarm systems, when you can provoke intervention by varying
1468 the set-point conditions,
- 1469 - proof of intervention on a sample of smoke or gas, simulating actual operating
1470 conditions.

1471 Similarly, the SMS section including procedures, organization, prevention policy etc. is
1472 analysed by the application of the check list approach, posing more emphasis on all
1473 preliminary identified critical topics. It is noteworthy noting that the SMS checklist allows
1474 highlighting safety management critical factors within the context of industrial parks, e.g.
1475 common services and utilities, combined emergency planning and periodical simulations,
1476 mutual connections and common maintenance, domino effects.

1477 Different types of documents result from inspections and the potential wider applicability of
1478 these documentations in the Italian safety domain is currently under investigation (Ansaldi et
1479 al., 2018).

1480 As noted in Fig. 9, the actual number of yearly inspections performed on upper tier
1481 establishments (Ricchiuti, 2014), coordinated by the MATTM, before the implementation of
1482 Seveso III Directive in Italy is quite inconstant and lower than the target envisaged by the
1483 directive, probably due to the need for more resources, knowledge and expertise at the local
1484 level.

1485 *Fig. 9 - Trend of Seveso upper tier inspections in Italy before the implementation of Seveso III*
1486 *Directive (Ricchiuti, 2014).*

1487 Seveso III implies new stipulations regarding the inspection of Seveso establishments, which
1488 are specifically enforced in Italy by art. 27 of D. Lgs 26 June 2015, n° 105 and published on
1489 14 July 2015. The new implementations in strict adherence to the European Directive expand
1490 and supplement the inspection domain borrowing some definitions from the Directive
1491 2010/75/CE "IED". In particular, Authorities are requested to develop in a systematic and
1492 plan-wise way:

- 1493 - a national inspection plan for upper tier establishments coordinated by ISPRA and the
1494 Ministry of Environment and Territory and Sea Protection (MATTM);
- 1495 - a regional inspection plan for lower tier establishments, properly coordinated,
1496 organized and planned on a yearly basis;
- 1497 - procedures for routine inspections (planned) and non-routine inspections (non-
1498 planned, but as a result of complaints, incidents, near miss, or failure to comply with
1499 Decree established obligations for instance).

1500 Furthermore, the yearly national inspection plan for Seveso establishments (routine
1501 inspections), to be developed by MATTM should take into proper consideration the following
1502 criteria:

- 1503 - substance and process hazards;
- 1504 - follow-up of previous inspections in the establishment;
- 1505 - possibility of domino effects between different establishments;
- 1506 - clusters of Seveso establishments in industrial parks;
- 1507 - vulnerability of the surrounding territory or presence of vulnerable targets in the area
1508 in relation with the hazardous material transmission mean;
- 1509 - need of attaining the frequency for lower tier Seveso establishments fixed by Seveso
1510 III on 3 years and for upper-tier Seveso establishments the minimal inspection
1511 frequency already set to be yearly by Seveso II.

1512 Inspection activity and effectiveness is strengthened by imposing to provide the operator of a
1513 follow-up with required actions within 4 months from the inspection. Additionally, in case of
1514 serious shortcomings in an establishment it is required a mandatory follow-up inspection
1515 within 6 months and it is foreseen the possibility of plant shut-down in case of serious non-
1516 compliances.

1517 6.4 - Seveso inspections in Spain

1518 The application of the Seveso III directive leads, in principle, to the application of more strict
1519 criteria. Inspections are addressed in Art. 21 of RD 840/2015 of September 21st as mentioned
1520 in Table 2.

1521 In this article the first point establishes that the competence for setting an appropriate system
1522 for inspections and control is a responsibility transferred to the relevant authorities in each
1523 autonomous community. Afterwards the general principles and targets for this system are
1524 described, which are equivalent to those described in the European Directive.

1525 The General Direction of Civil Protection issued a guidance for Seveso inspections in the
1526 frame of the RD 1254/1999 of 16 July 1999 which, as mentioned in Table 2, transposes the
1527 Seveso II Directive in Spain. This guidance has not been reviewed after the transposition of
1528 the Seveso III Directive. The aim of a stricter criteria and thoroughly inspection had a low
1529 impact in practical terms.

1530 In Spain, inspections can only be done by companies authorised by each competent
1531 administrative body of the autonomous community. Attention points are common as they
1532 fulfil the requirements defined in the Seveso Directive, nevertheless due to the lack of clear
1533 inspection checklist and considering the rather broad field defined by major accidents,
1534 administrations define key points based on their risk perception, past accidents in the
1535 industries they manage and risk acceptance and LUP criteria they define. Generally,
1536 inspections are characterised by being done by a single inspector and lasting between 1 and 3
1537 days.

1538 As in France in the case of the accident that took place in Rouen on 2019, September 26th, the
1539 accident of a Seveso company in Tarragona on 2020, January 14th, where a reactor containing
1540 around 4tn of Ethylene Oxide caused commotion among the community, authorities and
1541 industry. This accident is casting a shadow on the effective identification and control of major
1542 accident hazards.

1543 This detailed review of inspection practices in the four countries concerned shows the wide
1544 variety of procedures used. This observation will help to explain later the situation of the
1545 assessment of inspections by the EU Council.

1546

1547 6.5 – Assessment of inspections by the EU Council

1548 The overall importance of the implementation of Article 18 is first highlighted in the Calero
1549 evaluation report (2017). Indeed, inspection is a key aspect of the implementation of the EU

1550 Seveso II Directive as it is the opportunity for the competent authority to verify on site that
1551 the provisions of the Directive are in practice being applied. The Directive requires that upper
1552 tier establishments are inspected at least once per year. However, there is a flexibility
1553 included in the Directive which is that annual inspections are not required where the
1554 programme of inspections is based on a systematic assessment of major-accident hazards.
1555 Member States were requested to provide information on how many of their upper tier
1556 establishments were inspected annually, and of those that were not, how many had been
1557 inspected in the last three years. Similarly, while the Seveso Directive does not require a
1558 minimum frequency of inspections for lower tier establishments, Member States were asked
1559 to indicate how many of these establishments were subject to on-site inspections in the last
1560 three years. Finally, the questionnaire requested that those Member States where the
1561 programme of inspections is based upon a systematic appraisal of major-accident hazards
1562 report the criteria on which the systematic appraisal is based.

1563

1564 Based on the feedback from reports C 2010, COM 2017 and Calero 2017, it is possible to
1565 examine in a comprehensive way the implementation of inspections of Seveso establishments
1566 in the four countries concerned. According to the information provided, it appears that
1567 Germany and Italy have adopted a systematic appraisal. In Germany monitoring programmes
1568 are developed, defining the intervals and the extent to which inspections will be undertaken at
1569 individual sites. In Italy, an inspection system based on systematic appraisal of major-accident
1570 hazards has been introduced with the revision of the regulatory framework conducted in 2015.
1571 However, this does not concern the reporting periods considered in these reports. France
1572 indicated that such appraisal is not considered and inspections are based on regular deadlines.
1573 With some uncertainty, Spain indicated that due to the competence of its autonomous regions

1574 in inspection matters, it is unknown whether inspections are based on systematic appraisal or
1575 not.

1576

1577 The detailed compliance of four Member States with the inspection of establishments is now
1578 presented by way of the verbatim of a part of the Calero (2017) report:

1579

1580 France

1581 *“France is close to meeting the requirement of the article 18 of the EU Seveso II Directive. In*
1582 *France, there were a total of 1,178 establishments subject to the provisions of the Seveso II*
1583 *Directive in 2014, of which 639 (54% of the total) were upper-tier establishments. Inspections*
1584 *were carried out at least once during the reporting period for 100% of upper-tier sites and*
1585 *98% of lower-tier sites. Annual inspections were held in 611 establishments, representing*
1586 *96% of total upper tier establishments. The fact that 4% of upper tier establishments were not*
1587 *inspected annually is highlighted as an aspect of the implementation of the Directive that may*
1588 *warrant further investigations”.*

1589

1590 Germany

1591 *“The German response indicates that the provisions of the Seveso II Directive are almost*
1592 *fully implemented. The main gap observed relates to the large number of upper-tier*
1593 *establishments that were not inspected annually, with some not inspected at all during the*
1594 *reporting period. Note that Germany uses a systematic appraisal of major accident hazards to*
1595 *plan inspections. As such annual inspections are not required so this does not constitute a*
1596 *compliance issue but rather a potential issue that might need further checks. In Germany,*
1597 *there were a total of 3,264 establishments subject to the provisions of the Seveso II Directive*
1598 *in 2014, of which 1 141 (34% of the total) were upper-tier establishments. Inspections are*

1599 *planned based on a systematic appraisal of major-accident hazards; as such there is no*
1600 *obligation to inspect upper-tier establishments annually. Inspections were carried out at least*
1601 *once during the reporting period for 86% of upper-tier sites and 68% of lower-tier sites.*
1602 *Annual inspections were held in 422 establishments, representing 37% of total upper tier*
1603 *establishments. While not a compliance issue, the fact that 14% of upper tier establishments*
1604 *were not inspected over the reporting period is highlighted as an aspect of the implementation*
1605 *of the Directive that may warrant further investigations and the German competent*
1606 *authorities confirmed that this point would be investigated further”.*

1607

1608 Italy

1609 *“The Italian response indicates that most of the provisions of the Seveso II Directive are*
1610 *implemented. However, there were issues identified with some of the key provisions of the*
1611 *Directive, related in particular to the large number of upper-tier establishments that were not*
1612 *inspected annually.*

1613 *In Italy, there were a total of 1,112 establishments subject to the provisions of the Seveso II*
1614 *Directive in 2014, of which 567 (50% of the total) were upper-tier establishments. It is*
1615 *unclear why this requirement of the EU Seveso II Directive has not been implemented. Italy*
1616 *indicated that the low number of inspections was caused by organisational and financial*
1617 *constraints. Italy argued that its national legislation was amended in order to address this*
1618 *issue in the future reporting period (i.e. under Seveso III) by redrafting the competence for*
1619 *inspection and by providing financing for the inspections through tariffs paid by the*
1620 *operators”.*

1621

1622 Spain

1623 *“For Spain, the provisions of the Seveso II Directive are mostly implemented but gaps were*
1624 *observed in relation to key provisions of the Directive. It is unclear whether inspections are*
1625 *planned based on a systematic appraisal of major-accident hazards or not. Authorities*
1626 *carried out, on average, inspections at least once during the reporting period in 78% of*
1627 *upper-tier sites and in 56% of lower-tier sites during the reporting period. Annual inspections*
1628 *were held in 192 upper tier establishments, representing 51% of total upper tier*
1629 *establishments. This relatively low number of upper-tier establishments inspected annually*
1630 *may not be an issue (depending on how inspections are planned); however, it might be useful*
1631 *to verify this is the case. However, the fact that 22% of upper tier establishments were not*
1632 *inspected at all during the reporting period might indicate difficulties encountered in*
1633 *applying the requirements of the Directive at national or regional level. For Spain, this might*
1634 *be explained by the fact that some autonomous regions might base the programme of*
1635 *inspections on systematic appraisal of major accidents hazards. While requested, this*
1636 *information had not been provided by several regional authorities”.*

1637 For the concerned Members, Table 19 presents the number of inspections and the share of
1638 upper and lower tier establishments inspected at least once during the reporting period 2012 -
1639 2014

1640

1641 *Table 19 – Number and percentage of upper and lower tier establishments inspected at least*
1642 *once during period 2012 -2014 (adapted from Calero, 2017).*

1643

1644 It can be observed that the share of upper tier establishments inspected at least once are lower
1645 than 100 %. This is the case for Germany, Italy and Spain. But Germany has reported
1646 information concerning the adoption of an inspection program based on systematic appraisal,
1647 which could explain a lesser frequency that annual. For Italy and Spain, it is unclear why

1648 inspections were not conducted as required.

1649 The results of the inspection of lower tier establishments show an improvement compared to
1650 those observed in the previous report.

1651

1652 The main activities that inspectors should undertake to enforce the Seveso directives are as
1653 follows:

1654 - assessments of the safety report that the companies have to compile,

1655 - on - site inspections (at least once a year as the directives prescribe) to establish to what
1656 extent safety on paper has been put into practice in chemical plants.

1657 Many different types of expertise are required to carry out these two missions. Two countries
1658 (France and Germany) employ teams of inspectors who combine expertise in the fields of
1659 environmental and occupational safety, both to assess the safety report and to carry out the
1660 inspections. But Spain employs a different approach, using separate teams for assessment and
1661 inspection. For the assessment of the safety report, private consultants are used, while
1662 inspections are carried out by accredited Spanish industrial control organs.

1663 According to the last inspection stipulations enforced in Italy, inspection teams are appointed
1664 by the Regional Direction of the National Fire Brigade (CNVVF) for upper tier
1665 establishments and consist of three technical executives/officials from Institute for Accident
1666 Prevention and Safety at Work (INAIL), Italian Ministry of Interior CNVVF and the
1667 competent Regional Environment Protection Agency (ARPA), or from the Italian Institute for
1668 Environmental Protection and Research (ISPRA). For lower tier establishments, the Regional
1669 competent authority provides both inspection plan and teams appointments, mainly from the
1670 same Organizations.

1671 The eight essential elements of the Safety Management System for the prevention of major
1672 accidents (SGS-PIR) under verification during inspections utilizing the new check-list
1673 approach can be listed as follows:

- 1674 a) Policy document.
- 1675 b) Organization, responsibility and resources.
- 1676 c) Hazard identification.
- 1677 d) Operative monitoring and control.
- 1678 e) Management of change of technology, facility, or organization.
- 1679 f) Emergency management.
- 1680 g) Performance control.
- 1681 h) Audit, verification and corrective actions.

1682 The new inspection guidelines were fully applied in the last three years evidencing a rather
1683 increased trend in the actual number of inspections for upper tier establishments if compared
1684 to the previous mentioned inspection data shown in Fig. 9

1685 The valuable knowledge contained into the inspection documents archive is useful for
1686 addressing the inspectors' training, upgrading the inspection activity, disseminating safety
1687 information and improve the overall safety of the chemical industry in Italy (Ansaldi et al.,
1688 2019).

1689 The audit reports allowed identifying a number of non-compliance SMS elements
1690 characterized by an average percentage over the three-year period higher than 50%, which
1691 will likely recommend corrective actions and address better the future inspection targets. The
1692 identified critical SMS elements include: information, formation and personnel training;
1693 operative and monitoring control; emergency management and performance control
1694 (Battistella et al., 2020). Elaborating further inspection panels' findings, some specific
1695 improvement actions can be recommended, e.g.:

- 1696 - training and competence in process safety with proper indicators;
- 1697 - mechanical integrity (MI) indicators (inspections, controls and test schedules of
- 1698 - system components;
- 1699 - emergency periodical simulations not fully complying with emergency procedure
- 1700 envisaged in the SMS;
- 1701 - development of performance level indicators to measure SMS effectiveness;
- 1702 - maintenance and asset;
- 1703 - risk based inspection and maintenance especially in aging systems.

1704 In particular, ageing of plants and equipment, due to corrosion and other phenomena, is
1705 currently a problem recognised by the Seveso Competent Authorities producing also long-
1706 term environmental effects, which should concern also IPPC regulations (Bragatto et al.,
1707 2019). Starting from the critical results of actual findings on SMS during recent inspections of
1708 upper tier plants a methodology was built to stimulate the introduction of effective ageing
1709 management changes and related monitoring plan, into the safety management of companies
1710 (Vairo et al., 2018).

1711 Table 20 illustrates the different types of assessment and inspection activities in the four
1712 countries concerned. This table shows that the order of magnitude of the size of the inspection
1713 teams is approximately the same. Germany and Spain devote more time than France to the
1714 assessment and evaluation of safety reports, but for the latter the time spent by external
1715 expertise cannot be quantified. Finally, the duration of the annual inspection is identical in the
1716 four countries.

1717

1718 *Table 20 – Many different types of assessments and inspections activities.*

1719 In terms of implementation and standardisation of practices it is worth mentioning the Mutual
1720 Joint Visit Programme. which was launched in 1999 by the European Commission. This

1721 programme is intended to serve as a vehicle for promoting technical exchange among EU
1722 Member State, Candidate and EEA1 Seveso inspectors. The aim of the programme is to
1723 encourage the sharing and adoption of best practices for inspections through a system of
1724 regular information exchange. The visits are hosted by different Seveso implementing
1725 countries (hence visits would be “mutual”) and targeted for working inspectors of other
1726 Seveso countries (and thereby “joint” visits) charged with assessing compliance with the
1727 Seveso Directive in industrial installations. The MJV Programme is managed by the JRC's
1728 Major Accident Hazards Bureau in consultation with the TWG on Seveso Inspections. (MJVs,
1729 2005). The detailed assessment of this programme was drawn up by Wood (2004) to show the
1730 interest in jointly developing a better understanding of what constitutes compliance and the
1731 notion of acceptable safety risk in the context of the inspection of Seveso establishments. In
1732 the same way, Kotisalo (2016) has developed a scoring system for evaluation criteria capable
1733 of better supporting inspectors. The thesis reports the detailed protocol tested by different
1734 teams of inspectors during inspection visits to nine Seveso establishments in seven different
1735 European countries. Analysing the practical implementation of the Seveso Directives during
1736 inspections in the Netherlands, Versluis et al (2010) suggest that the uncertainty in the
1737 assessment of certain risks, which are themselves considered blindly, should be examined
1738 with a tolerance uncertainty, but accepting a necessary societal cultural change.

1739 **7 – Conclusions**

1740 The present paper is an assessment of the implementation and completeness of the EU Seveso
1741 Directives in the four Member States France, Germany, Italy and Spain. Its preparation
1742 showed the difficulties in identifying the similarities and differences as well as the strengths
1743 and weaknesses of the procedure in each country. Feedback from the various reports
1744 submitted by the Member States and examined by the European Council shows that
1745 implementation has been satisfactory overall, but that progress is still necessary.

1746 Among the various items examined, the difficult subject of inspections remains very much in
1747 evidence. First of all, suggestions to improve the follow-up of inspections are listed, such as
1748 questions on the training of inspectors at the national level, on the deficiencies identified
1749 during inspections for the reference period and the measures taken to remedy them, on the
1750 deficiencies identified during the testing of contingency plans during the reference period and
1751 the measures taken to remedy them. However, for the time being, the implementation of these
1752 suggestions is postponed to the period 2019-2023 due to the fact that the deadline for
1753 updating the questionnaire is too close. This is well confirmed by the lack of available
1754 minutes of the Seveso expert group in 2019.

1755 Next concerning the role of inspection, section "5 - Control and inspection practices in the
1756 states" of this article highlighted the diversity of approaches and practices used in France,
1757 Germany, Italy and Spain. Despite the important purpose of implementing inspections, this
1758 unsatisfactory situation is comparable in the various Member States of Europe. It is therefore
1759 interesting to take up and share the turning point text underlined by Lindhout, the first author,
1760 retired as an inspector (Lindhout and Reniers, 2017):

1761 *“While drilling down further into the details of a risk assessment, a point is reached at which*
1762 *the inspector is no longer able to assess whether the study is robust and complete. The*
1763 *inspector is e.g. faced with highly specialized chemical knowledge, a mix of old and new*
1764 *technology, a wide variety of degradation mechanisms, an installation design made by third*
1765 *parties and with ‘open’ web-integrated ICT based control systems. He is confronted with*
1766 *some-times colossal, yet incomplete, quantities of information and is notable to follow in all*
1767 *the footsteps of the many people that prepared this information, and verify, let alone grasp*
1768 *whether it is sound, consistent and complete as a risk assessment. He can only say -*
1769 *frustrating as it is - he cannot see any shortcomings”.*

1770 Finally, it also appears that the importance of the evaluation of inspections of Seveso

1771 establishments cannot be reduced to simple numerical indicators. It is recommended that
1772 more unified, shared and accepted approaches to risk assessment should be promoted at the
1773 European level. The template questionnaire submitted to the Member States should be more
1774 exhaustive, so that the quality of the implementation can be monitored and verified through a
1775 thorough inspection. For example, the integration of information related to the Safety
1776 Management System should be mandatory, due to its almost paradigmatic importance, despite
1777 possible difficulties in its implementation. Nevertheless, the application of such decision is a
1778 political responsibility related to society's choices and not only to technical or scientific
1779 limitations. The simultaneous presence of an active process safety culture among all
1780 stakeholders involved in the implementation process is essential to enable it to be validated
1781 internally within the establishments and externally by the supervisory authorities.

1782

1783 **Declaration of interests**

1784 The authors declare that they have no known competing financial interests or personal
1785 relationships that could have appeared to influence the work reported in this paper.

1786

1787 **Disclaimer**

1788 The views and opinions expressed in this article are those of the authors and do not
1789 necessarily represent those of others.

1790

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2228 **TABLES**

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- 2264 Table 1 – Overview of some industrial accidents for the period 1970 – 2018 (Extract from the
2265 databases Aria - eMars and Zema).

Country	Location	Year	Episode	Fatalities	Injured
1970 – 1982 before EU Seveso I directive					
France	Perpignan	1970	BLEVE of a LPG tank wagon	2	49
Spain	Alcanar camping Los Alfaques	1976	BLEVE of a liquefied propylene tank truck	215	>200
France	Saint Amand les Eaux	1973	Propane VCE in a road tank car	9	37
Italy	Seveso	1976	2,3,7,8, TCDD (Dioxine) release following runaway and rupture disc activation of a batch reactor	-	220,000 people exposed
Spain	Oviedo province	1978	Rail tank car gasoline fire and explosion	7	
1982 – 1996 before EU Seveso II directive					
Italy	Priolo	1985	Explosion of propylene in an ethylene plant	0	4
France	Villers Saint Paul	1989	Explosion of a 1000 m ³ benzene tank	1	2
France	Noyelles - Godault	1993 1994	Explosion of a zinc refining column	10 1	1 7
Italy	Palermo	1996	Collision in a highway tunnel and propane BLEVE	5	34
1996 – 2012 before EU Seveso III directive					

Germany	Bergkamen	1998	Explosion of transport containers for organo-metallic compounds	1	
France	Toulouse	2001	Ammonia nitrate explosion	29	>2,000
Italy	Napoli	2003	Explosion of a nitrogen tank in a varnish company	4	
France	Harnes	2003	air cooling towers petrochemical site (legionellosis)	18	83
France	Billy-Berclau	2003	Manufacture of explosive products	4	9
Spain	Puertollano	2003	Explosion and domino effect in a FCC unit at refinery	9	10
Italy	Ancona	2004	Explosion and fire during reaction facility	1	3
Italy	Priolo	2006	Pool fire in a crude oil pipeline	0	2
France	Gonfreville	2009	Explosion of a sulfuric tank	0	5
France	Saint Avold	2009	Explosion of a super-heater within a steam cracking unit	2	4
Italy	Viareggio	2009	Derailment of LPG tank wagons followed by UVCE explosion and intense fire	32	1,000 evacuated
Germany	Ibbenbüren	2009	Explosion in chlor-alkali plant due to a lightning stroke into the power supply	0	2
France	Manosque	2010	Rupture of a pipeline within an underground hydrocarbon storage facility in saline cavities	0	3
2012 – 2018 after EU Seveso III Directive					
Germany	Brühl	2012	Release of chlorine in an electroplating plant as result of mistakenly filling sodium hypochlorite to a hydrochloric acid container	4	36
Germany	Marl	2012	Explosion and fire in a plant for the production of Cyclododecatriene during plant start-up	2	1
Italy	Citta Sant' Angelo	2013	Serie of mass explosions in a fireworks factory	5	8
France	Marseille	2014	Leak and explosion of natural gas during welding on an underground pipeline	1	6
Germany	Pirna	2014	Thermal explosion of reactor and release of trimethyl phosphite in a chemical plant	1	4
France	Jouy	2015	Overpressure and explosion in an hydrogen peroxide tank	1	3
Spain	Saragosse	2015	Series of deadly explosions in a fireworks factory	6	5
Germany	Ludwigshafen	2016	Fire and explosion during maintenance work on ethylene and propylene pipelines	3	30
Italy	Bologna	2018	LPG BLEVE of a tank truck hit by another truck on a highway viaduct	1	100

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France	Germany	Italy	Spain
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2279 Table 2 – Inventory of the national laws and decrees transposing the EU Seveso regulations.

Seveso I			
<p>-Law of 19 July 1976 on installations classified for the purposes of environmental protection. --Decrees of 21 September 1977 and 19 December 1986. -Circular of 28 December 1983. -Circular of 2 August 1985, as amended on 8 July 1986. - Inter-ministerial Circular and Instruction of 12 July 1985, "ORSEC technological hazards".</p>	<p>-Federal Immission Control Act. -Twelfth Ordinance on implementing the Federal Immission Control Act (Major Accident Ordinance). -1st, 2nd and 3rd Administrative regulation for the Major Accident Ordinance.</p>	<p><i>Decrees:</i> 16 November 1983, 2 August 1984, 11 June 1986 <i>Circulars:</i> 1 December 1982, 11 January 1986, 20 June 1986, 19 December 1986 <i>Decree:</i> 23 December 1985 <i>Regulation:</i> 22 February 1985 <i>Circular:</i> (Public Health): 1 April 1985 -Prime Ministerial Implementing Order: 18 December 1985 -Presidential Decree Ministry of Labour: 29 July 1982. DPR - Decree n° 175 of 07 May 1988 of the President of the Republic implementation of EEC directive 82/501 of 24 June 1982 on the major-accident hazards of certain industrial activities GU n°127, June 10, 1988.</p>	<p>Spain became member State of the EU on January 1st, 1986. The Directive Seveso I entered into force only on 1 January 1986 in Spain. Royal Decree 886/1988, of 15 July, on the prevention of major accidents in certain industrial activities. BOE, 5th August. 1988. Royal Decree 952/1990 of 29 June 1990 amending the Annexes and supplementing them supplementing the provisions of Royal Decree 886/1988 of 15 July 1988 on the following matters prevention of major accidents in certain industrial activities. BOE, 21st July 1990. Resolution of 30 January 1991 of the Under-secretariat publishing the Agreement on the International Council of Ministers approving the Basic Directive for the elaboration and implementation of the homologation of Special Plans for the Chemical Sector BOE, 6th June 1991.</p>
Seveso II			
<p>-Decree of 20 March 2000 amending the decree of 21 September 1977 adopted for the application of the law of 19 July 1976 on classified installations, -Decree of 28 December 1999 amending the decree of 20 May 1953 on the nomenclature of classified installations, -Ministerial order of 10 May 2000 specifying in particular the provisions</p>	<p>-Fifth Amendment to the Federal Immission Control Act (BlmSchG) in the applicable Version of 19 October 1998 -Major Accident Ordinance from 26th April 2000, (Federal Law Gazette I p. 603) becoming effective on 03rd May 2000.</p>	<p>Law n° 137 of 19 May 1997 Sanatorium of decrees law amending the Decree of the President of the Republic 17 May 1988, n° 175, on the risks of major accidents related to certain industrial activities. GU n°120 June 26, 1997. Legislative Decree n°334,</p>	<p>Royal Decree 1254/1999 of 16 July 1999 approving measures to control the risks inherent in serious accidents involving dangerous substances. BOE, 20th July 1999. Royal Decree 1196/2003 of 19 September 2003 by which the Basic Directive of Civil Protection for the control and planning in front of major accidents</p>

<p>to be implemented by operators with regard to major-accident prevention policy and laying down the categories of installations covered by these obligations, -Ministerial circular of 10 May 2000, explaining the major innovations introduced by the above texts.</p> <p>Law n° 2003-699 of 30 July 2003 on the prevention of technological and natural risks and the repair of damage.</p>		<p>17 August 1999 GU n°228, September 28, 1999.</p> <p>Legislative Decree n°238 21 September, 2005 GU n°271, September 21, 2005.</p>	<p>hazards in which hazardous substances are involved is approved. BOE, 9th October 2003.</p>
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Seveso III

<p>- Act DDADUE No. 2013-619 of 16 July 2013 on various provisions for adapting to European Union law in the field of sustainable development (JORF n°0164 of 17 July 2013)</p> <p>-Decree No. 2014-284 of 3 March 2014 amending Title I of Book V of the Environmental Code -Decree No. 2014-285 of 3 March 2014 amending the nomenclature of classified installations for the protection of the environment -Order of 11/05/2015 amending a series of ministerial orders to take into account the new nomenclature of classified installations for the protection of the environment, which came into force on 1 June 2015 as part of the transposition of Directive 2012/18/EU -Order of 26/05/2014 on the prevention of major accidents in classified installations mentioned in Section 9, Chapter V, Title I of Book V of the Environmental Code (OJ No 133 of 11 June 2014) of 4 July 2012.</p>	<p>-Federal Immission Control Act (BlmSchG) in the applicable Version of the bulletin from 17th May 2013 latest amended by article 1 of the law from 8th April 2019 (Federal Law Gazette I p. 432).</p> <p>-Major Accident Ordinance in the version of the announcement of 15th March 2017, latest amended by article 1a of the ordinance from 8th December 2017 (Federal Law Gazette I p. 3882).</p> <p>-<i>Länder</i> administrative regulations and decrees on the implementation of the major accident ordinance.</p>	<p>Legislative decree n° 105 of 26 June 2015 implementation of directive 2012/18/EU on the control of major-accident hazards involving dangerous substances. GU n°161, July 14, 2015.</p>	<p>Royal Decree 840/2015, of September 21, approving measures to control the risks inherent to serious accidents involving dangerous substances. BOE, 20th October 2015.</p>
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2296 Table 3 – Main competent and implementing authorities responsible for the application of the
 2297 EU Seveso I – II and III directives.

France	Germany	Italy	Spain
<p><i>National authorities</i> -Ministry for the Environment (Department for Classified Installations) - Ministry of the Interior (Disaster relief services)</p> <p><i>Local authorities</i> -Prefects-Chief Commissioners of the Republic (at Department level) - the Mayors</p>	<p><i>Federal authorities</i> -Ministry for the Environment, Nature Conservation and Nuclear Safety -Ministry of Labour and Social Affairs -Ministry for Building, Regional Planning and Urban Development -Ministry of the Interior</p> <p><i>Länder authorities</i> -Landesministerien für Umwelt, Naturschutz, Landschaftspflege etc. (State Ministries for Environment, Nature Protection, Landscape conservation etc.) -Regierungspräsidien (Governmental Presidia) -Bezirkregierung (District Governments) -Gewerbeaufsichtämter (Trade Supervisory Authorities)</p>	<p><i>National authorities</i> -Ministry of Environment, Atmospheric, Acoustic and Industrial Pollution -Ministry of Industry, Directorate-General for Energy Sources, -Ministry of the Interior-Directorate General of Civil Protection and Fire Services. -Ministry of Health</p> <p><i>Regional and Province authorities</i> -Regional and Provinces Governments -Prefectures Municipalities -Regional technical Committee for the Coordination of Safety Procedures -Inter-ministerial Coordinating Committee -National body fire brigades. -The Fire Department's inspectorate</p>	<p><i>National authorities</i> -Directorate-General of Civil Protection-Ministry of the Interior in coordination with the National Department of Industry, Environment and Labour, and with the national civil protection services of each province</p> <p><i>Autonomous communities</i> In general it is the department in charge of the tasks of civil protection in each Community which coordinates the implementation of the Directive in its area, with other regional departments such as industry, environment, labour, etc.</p> <p><i>Local authorities</i> The different municipalities concerned have to develop their external emergency plans following the guidelines given by their autonomous community.</p>

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Table 4 – Evolution of the number of upper-tier Seveso establishments (2005 – 2014).

Year	France	Germany	Italy	Spain	Total
2005 upper	593	976	462	245	2,276
2008 upper	553	1,077	518	295	2,243
2011 upper	622	1,104	533	332	2,591
2014 upper	639	1,141	567	377	2,724
2014 lower	539	2,123	545	455	3,662

Table 5 – Some potential values of the total number of Seveso establishments (year 2004).

Member State	France	Germany	Italy	Spain
Total number of Seveso establishments				
per Member State	1,178	3,264	1,112	832
per million inhabitants	16.7	29.5	18.7	13.5
per regional area in 1,000 km ²	1.75	6.71	3.76	1.60
per unit GDP in billions €	0.52	0.82	0.71	0.61

Table 6 – Brief overview of the LUP practices in 1999 (adapted from Christou et al., 1999).

Member State	Generic safety distances	Consequence based approach	Risk based approach	LUP criteria	Arrangements still being developed
France		X		X	
Germany	X	X		X	
Italy					X
Spain		X			X

Table 7 – Hazard/risk assessment methods used in LUP (reference year 2004) (adapted from Basta and Struckl, 2004).

Member State	Full probabilistic	Probabilistic with preselected scenarios	Consequence based approach (worst case scenario)	Consequence based approach (preselected scenarios)	Semi quantitative method
France			X		
Germany		X		X	
Italy					X
SP Galicia	X				
SP Bask countries			X		
SP Catalonia	X				

Table 8 – Territorial categories and Italian urban planning.

Territorial category	Urban planning
A	Residential areas with building land index $> 4,5 \text{ m}^3/\text{m}^2$; hospital > 25 patients; nursing / primary schools > 100 pupils; commercial centre/ daily markets > 500 people.
B	Residential areas with building land index in the range $1,5\text{-}4,5 \text{ m}^3/\text{m}^2$; hospital < 25 patients, primary and secondary schools < 100 people; university, commercial centre/ markets > 500 people; church, sports ground > 100 people (open) 1000 people (closed); railway station , port > 1000 passenger/day.
C	Residential areas with building land index in the range $1\text{-}1,5 \text{ m}^3/\text{m}^2$; secondary school, university; commercial centre/ markets < 500 people; church, sports ground < 100 people (open) 1000 people (closed); railway station, port < 1000 passenger per day.
D	Residential areas with building land index in the range $0,5\text{-}1 \text{ m}^3/\text{m}^2$; monthly gathering place (exposition markets, graveyard).
E	Residential areas with building land index $< 0,5 \text{ m}^3/\text{m}^2$; industrial establishments.
F	Industrial establishments and non-built respect area.

Table 9 – Correspondence between generic level of human health damage and level of harm selected by the four Member States (adapted from Cherrier, 2014).

Member State	Level 1 No effect	Level 2 Small effect	Level 3 Reversible injury	Level 4 Irreversible injury	Level 5 Start of lethality	Level 6 High lethality
France			Reversible effects SER	Irreversible effects SEI	Lethal effects SEL Heavy hazard 1%	Lethal effects SELS Very heavy hazard 5%
Germany			Reversible effects	Irreversible effects		
Italy			Reversible effects	Irreversible effects	Start of lethality	High lethality
Spain			Alert zone ZA	Intervention zone ZD		

Table 10 – Overview of thresholds for overpressure (mbar) (adapted from Cherrier, 2014 and KAS 18, 2010).

Member State	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Domino
France			20	50	140	200	200-300
Germany		Endpoint practice value 100					
Italy			30	70	140	200	300
Spain			50	125			160-350

Table 11 – Overview of thresholds for thermal radiation (Kw/m^2) (adapted from Cherrier, 2014 and KAS 18, 2010).

Member State	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Domino
France	Stationary heat rate			3	5	8	20-200
France	Nonstationary thermal dose (kW/m^2) ^{4/3} s			600	1,000	1,800	
Germany	Endpoint practice value 1.6 kW/m^2						
Italy			3	5	7	12.5	12.5
Spain	Nonstationary thermal dose (kW/m^2) ^{4/3} s		115	250			12 unprotected 37 protected

Table 12– Overview of toxic criteria (adapted from Cherrier, 2014).

Effect	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Member State	no effect	small	reversible	irreversible	lethal 1%	lethal 5%
France	-	-	-	SEI	SEL 1%	SEL 5%
Germany	Endpoint	ERPG 2	ERPG 2	ERPG 3		
Italy	-	-	-	IDLH	-	LC 50
Spain	-	-	AEGL 1	AEGL 2	-	-
	-	-	ERPG 1	ERPG 2	-	-
	-	-	TEEL 1	TEEL 2	-	-

Table 13 – LUP decisions based on the LPG facility analyses (adapted from Gyenes et al. 2017).

Location building	Type building	Distance (m)	Development allowed
A	School	1,000	All
B	House	900	All
C	House	800	All
K	Office	800	All
D	House	700	All
E	House	600	All
F	House	500	P1, P2, P4, P5, P6, P7, P8
G	House	400	P1, P2, P4, P5, P6, P7, P8
H	House	300	P1, P2, P4, P5, P6, P7, P8
I	House	200	P2, P5
J	Office	100	P5, P6

Table 14 - Range of number of people exposed to hazard for severity assessment in France.

Gravity	Lethality 5%	Lethality 1%	Irreversible injuries
Disastrous	> 10	> 100	> 1000
Catastrophic	1 – 10	10 – 100	100 – 1000
Major	1	1 – 10	10 – 100
Serious	0	1	1 – 10
Moderate	0	0	< 1

Table 15 - Land use compatibility matrix: physical effects vs. probability class for Seveso establishments in Italy.

Probability class [y ⁻¹]	Physical Effects			
	High lethality	Starting lethality	Irreversible injuries	Reversible injuries
< 10 ⁻⁶	DEF	CDEF	BCDEF	ABCDEF
10 ⁻⁴ – 10 ⁻⁶	EF	DEF	CDEF	BCDEF
10 ⁻³ – 10 ⁻⁴	F	EF	DEF	CDEF
> 10 ⁻³	F	F	EF	DEF

Table 16 – Evaluation matrix for Land Use Planning in France.

		PROBABILITY				
		E	D	C	B	A
GRAVITY	Disastrous	NO/MMR2	NO	NO	NO	NO
	Catastrophic	MMR1	MMR2	NO	NO	NO
	Major	MMR1	MMR1	MMR2	NO	NO
	Serious			MMR1	MMR2	NO
	Moderate					MMR1

Table 17 - LUP compatibility of existing, or planned vulnerable targets in the given industrial area, according to Italian and French criteria (Contini, 2010).

Vulnerable target	Distance (m)	Italy LUP	France LUP
Nursing school	370 N	In-compatible	Compatible
Graveyard	185 NE	Compatible	Compatible/Incompatible
Sports ground	215 SE	Compatible	Compatible
Church	830 NNO	Compatible	Incompatible
Commercial centre	700 NO	Compatible	Compatible
Private hospital	750 NE	Compatible	Compatible
New supermarket	250 N	Compatible	Incompatible

Table 18 – Number of annually inspected upper-tier Seveso establishments in Germany.

Country (Bundesland)	Number of upper tier Seveso establishments with annual on-site inspections
Baden - Württemberg	117
Bayern	62
Berlin	0
Brandenburg	15
Bremen	11
Hamburg	34
Hessen	5
Mecklenburg-Vorpommern	6
Niedersachsen	107
Nordrhein – Westfalen	6

Rheinland - Pfalz	13
Saarland	11
Sachsen	17
Sachsen – Anhalt	0
Schleswig – Holstein	11
Thüringen	7
Germany	422

Table 19 – Number and percentage of upper and lower tier establishments inspected at least once during the reporting period 2012 – 2014 (adapted from Calero, 2017)

Member State	France	Germany	Italy	Spain
Inspected upper tier number	660	981	115	295
% inspected upper tier	100	86	20	78
Inspected lower tier number	528	1436	268	255
% inspected lower tier	96	68	49	56

Table 20 – Many different types of assessments and inspections activities.

Member State	Inspection bodies involved	Size team of inspectors	Days per assessment of a safety report	Yearly inspection days per establishment	Reference
France	DREAL, DRT Labour Directorate	minimum 2	3 - 7	1 - 4	DREAL Grand Est
Germany	Environmental inspectorate, Labour inspectorate	2 - 4	10 - 30	1 - 5	Jutta et al (2008)
Italy	Ministry of Environment and Territory, System of the Protection Agencies of Environment (APAT/ARPA/APPA), Fire Brigades, Institute for Accident Prevention and Safety at Work	3	n/a	n/a	Schabel & Kontic (2005)
Spain	Private consultants (assessment) Accredited control organs (inspection)	1 – 2 1 - 2	5 - 20	1 - 5	Jutta et al (2008)

FIGURES

Fig. 1 - Overview of different approaches to LUP in the different European Countries.

Fig. 2 - Schematic flow sheet for the semi quantitative approach to land use compatibility.

Fig. 3 – Schematic map of LUP development around the LPG establishment.

Fig. 4 - Concentration of chlorine versus distance from a scenario considering the guillotine breakage of a valve at the bottom of a spherical liquified chlorine storage tank.

Fig. 5 - Distances of concern for ammonia in case of a scenario defined in a vessel of 3 m³ releasing its inventory in 1 minute (Pey et al., 2009).

Fig. 6 - Individual risk map (1/year) considering all accident scenarios in the given area with vulnerable targets (Contini, 2010).

Fig. 7 – Land Use Planning in the given area according to the Italian criterion (Contini, 2010).

Fig. 8 - Land Use Planning in the given area according to the French criterion (Contini, 2010).

Fig. 9 - Trend of Seveso upper tier inspections in Italy before the implementation of Seveso III Directive (Ricchiuti, 2014).

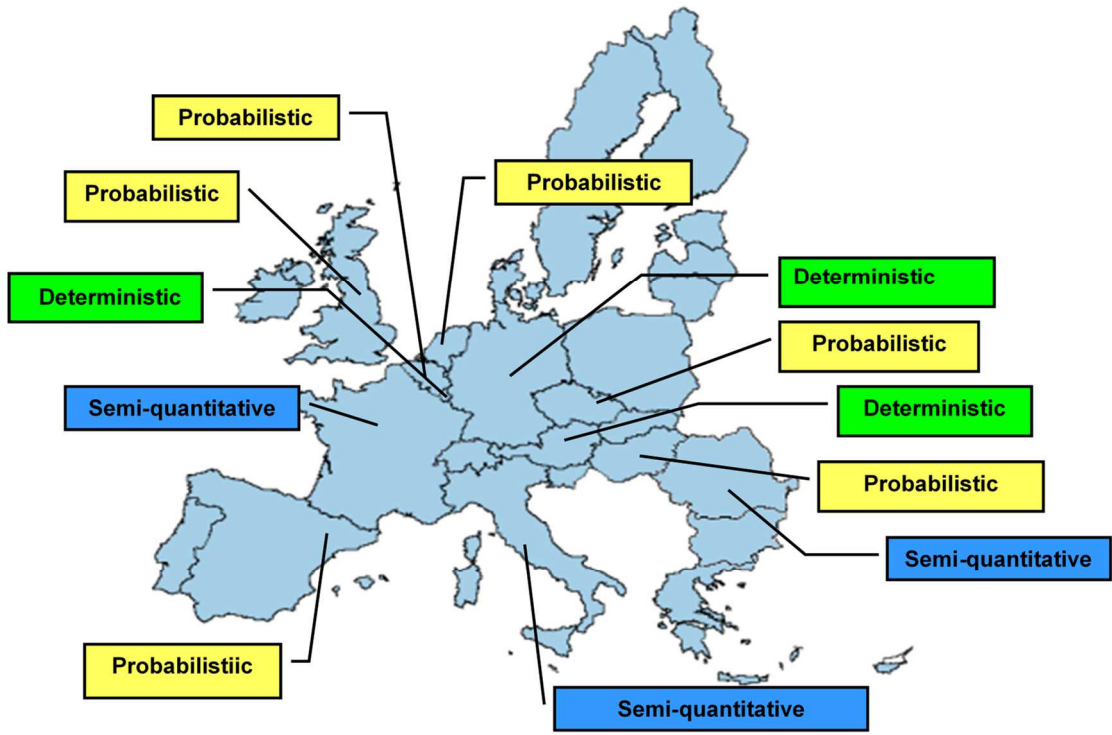


Fig. 1 - Overview of different approaches to LUP in the different European Countries.

Semi quantitative approach

- Each target point in the given area (x,y)
- Each k-th accidental scenario

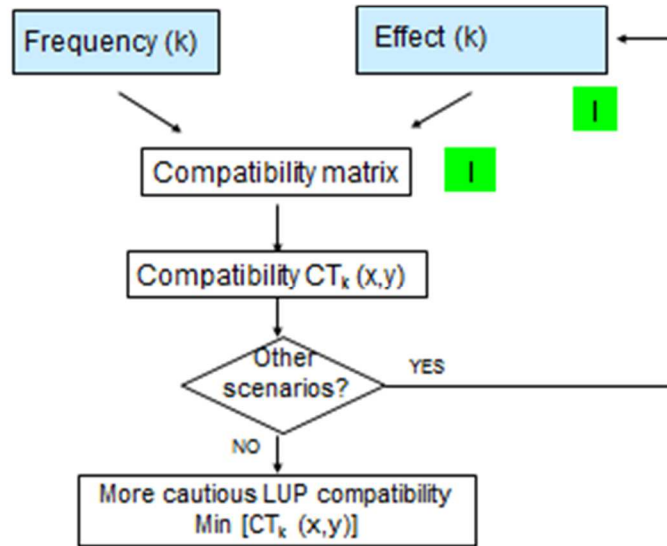


Fig. 2 - Schematic flow sheet for the semi quantitative approach to land use compatibility.

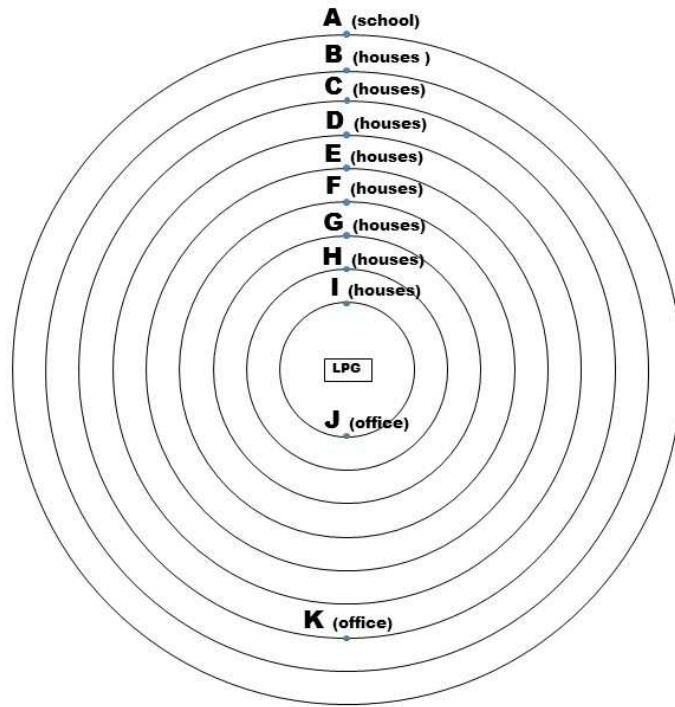


Fig. 3 – Schematic map of LUP development around the LPG establishment.

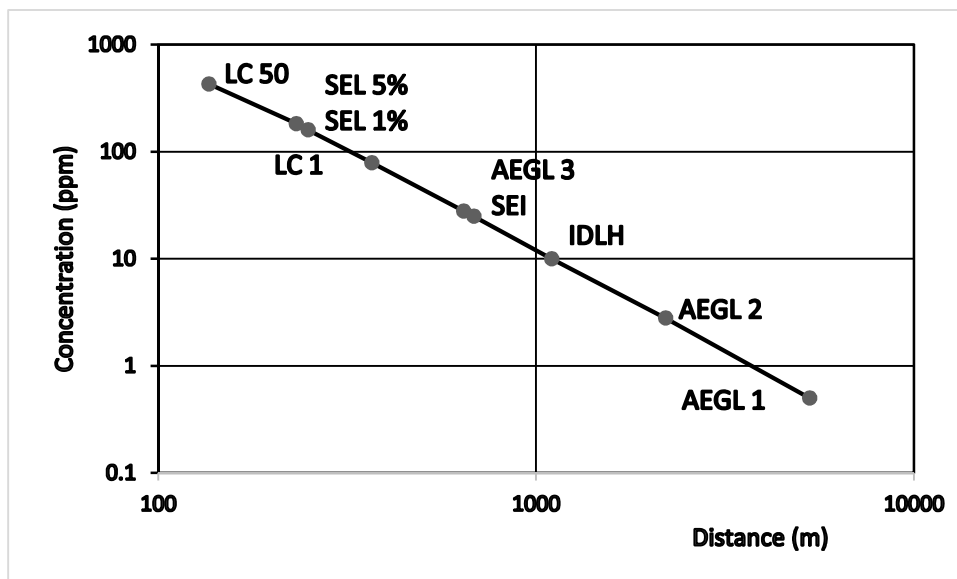


Fig. 4 - Concentration of chlorine versus distance from a scenario considering the guillotine breakage of a valve at the bottom of a spherical liquified chlorine storage tank.

Full Rupture of Storage Tank

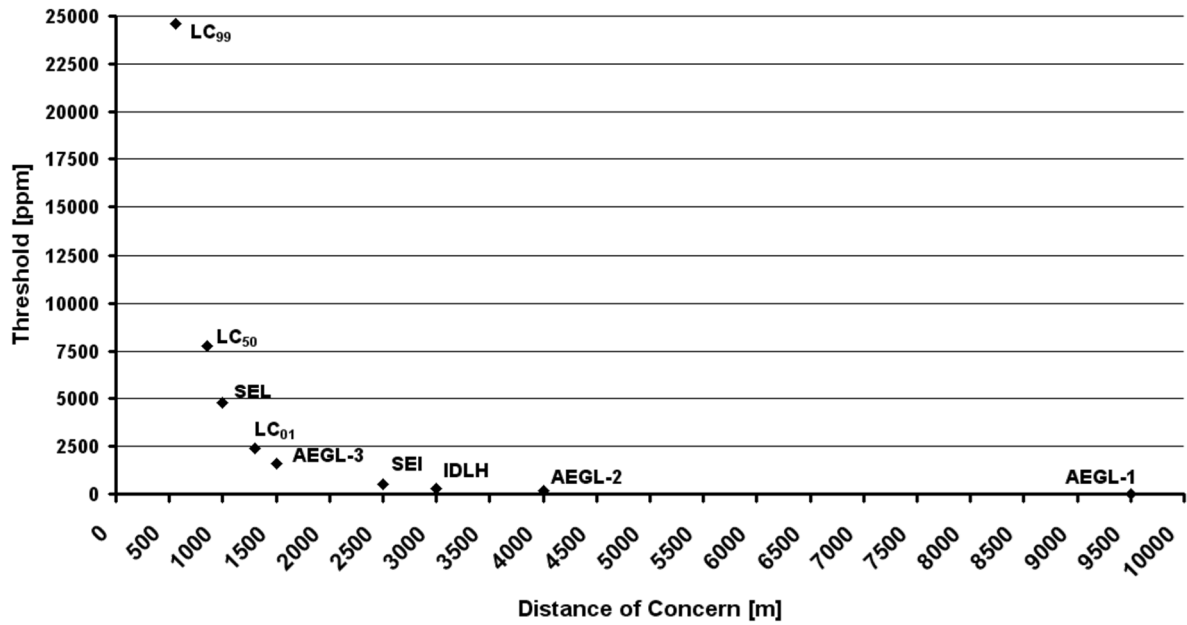


Fig. 5 - Distances of concern for ammonia in case of a scenario defined in a vessel of 3 m³ releasing its inventory in 1 minute (Pey et al., 2009).

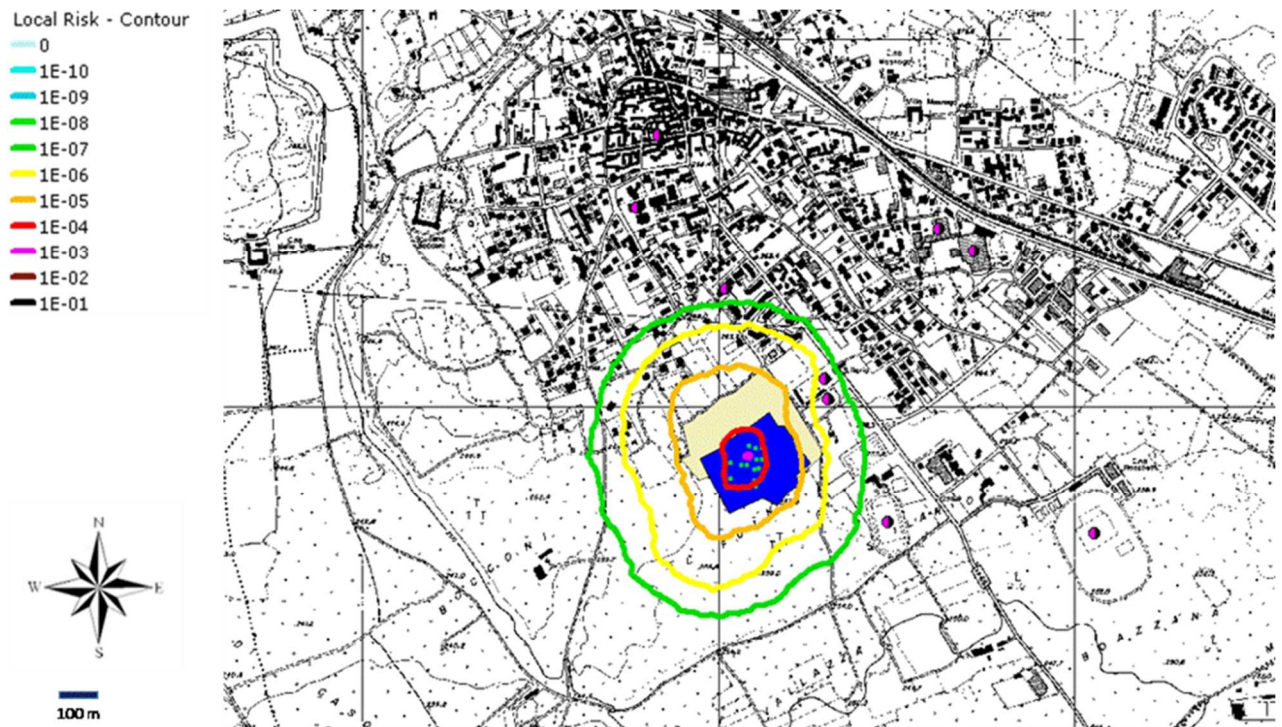


Fig. 6 - Individual risk map (1/year) considering all accident scenarios in the given area with vulnerable targets (Contini, 2010).

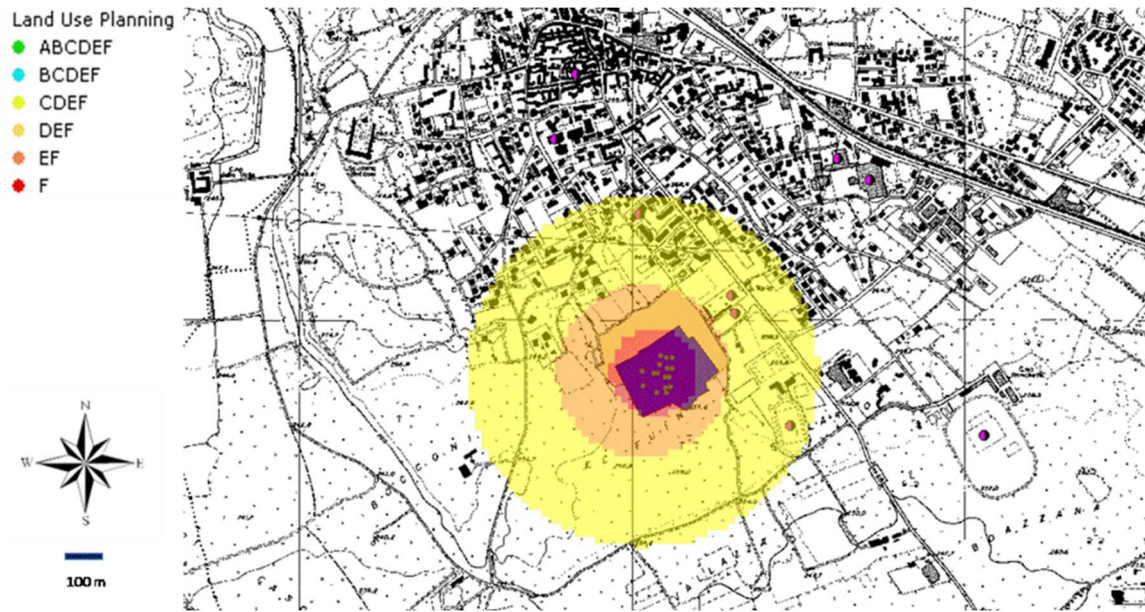


Fig. 7 – Land Use Planning in the given area according to the Italian criterion (Contini, 2010).

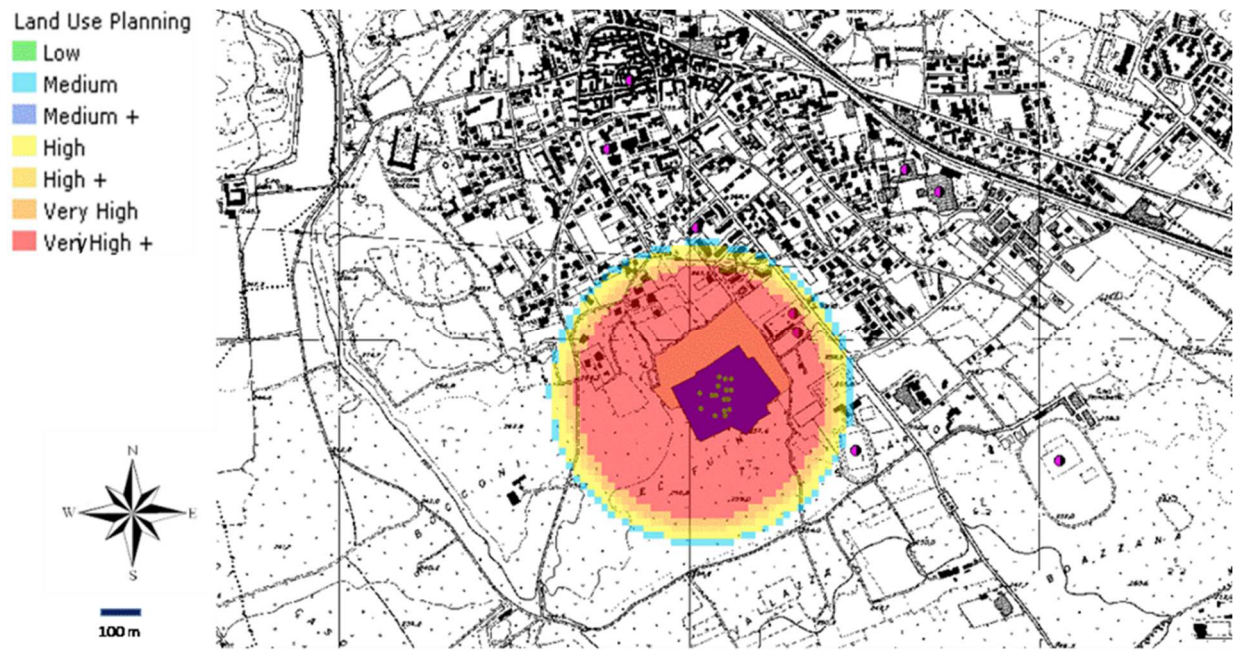


Fig. 8 - Land Use Planning in the given area according to the French criterion (Contini, 2010).

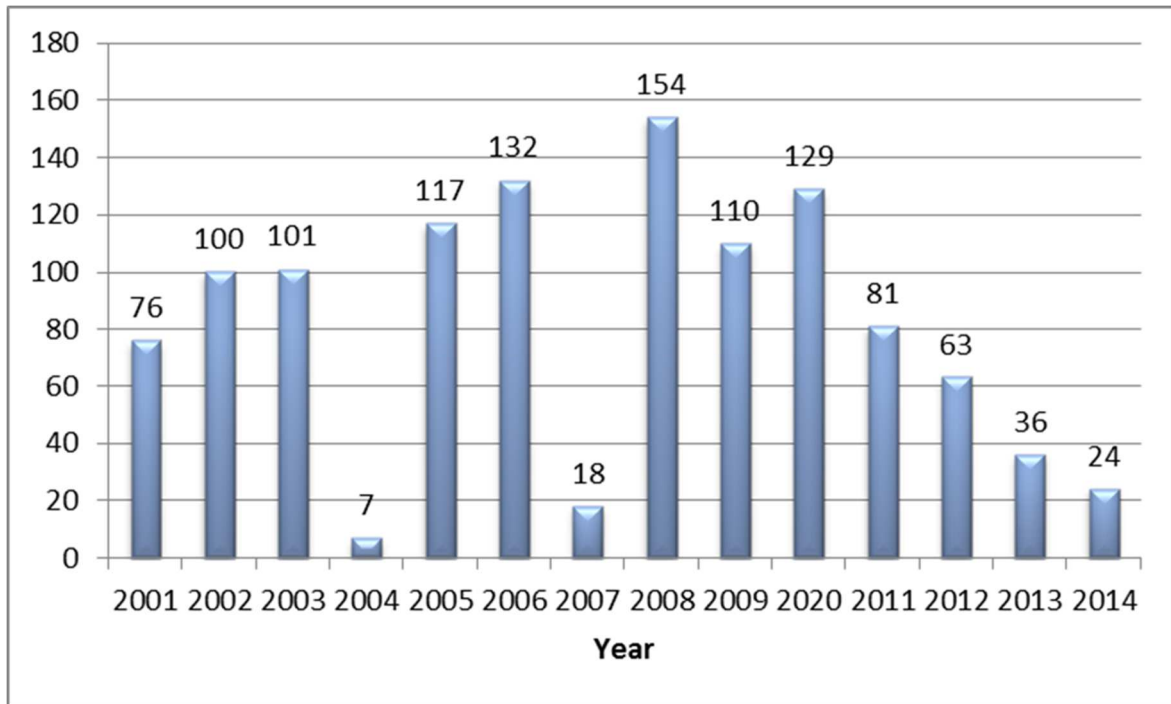


Fig. 9 - Trend of Seveso upper tier inspections in Italy before the implementation of Seveso III Directive (Ricchiuti, 2014).