

*Special Session on Experience Sharing around the French Practical Approach of
Seismic Security Engineering and Risk Management*

Example of Overall Seismic Security Engineering

High Risk Industries in France: Joint Action by Public Authorities, Owners/Operators & the French Association for Earthquake Engineering for a safe design and operation taking into account the seismic hazard

Jean-Philippe GIRARD*, Alain PECKER*, Pierre SOLLOGOUB* & Marc BOUCHON*

*Association Française de Génie Parasismique (AFPS)¹, Paris, France. E-mail: afps@enpc.fr

ABSTRACT: Consideration of earthquake in the design of different types of constructions has been recently updated in the **French regulation**. Sets of documents for the zoning, the hazard level, the screening of buildings and facilities, the criteria for the design, the design and construction guidelines were thus produced to be taken into account by the architects, engineering and design offices, owners/operators.

High risk industries are those for which the impact, in case the process could be impaired, may result in consequences outside the site of the facility. This category includes chemical, biological, oil&gas industries except nuclear facilities regulated under another framework.

A **hierarchy of documents**, decrees, ministerial rulings provides the reference prescriptive documents that shall be fulfilled by owners/operators. A joint action of Public Authorities, Owners/Operators & the French Association for Earthquake Engineering (AFPS) has been promoted in order to ease the application of these requirements in a wide set of industries. Owners were represented by members of association organized by typology. The documents produced by these working groups were validated by the Ministry and published as guidance for free use by the designers and operators.

Keywords: earthquake, industry, regulation, France

1. INTRODUCTION

Even though France is a country with moderate seismicity, historical data show some significant risk on specific faults, resulting, for instance, in 1909 in a MSK IX intensity earthquake, south of France with a death toll of 40 people. As not only housing needed prescriptive rules, a set of specific "shall" documents (that must be applied) have been published in the French gazette on how to design new facilities or upgrade old ones. The presentation focuses on High Risk Industries (outside nuclear facilities).

2. ZONING AND FACILITY SCREENING

According to the October 22nd, 2010 Decree, continental France is mapped with four intensity zones (very weak to medium). The resolution of the zoning is a set of towns called county (Figure 1).

Facilities are then sorted in three main categories:

- Standard risk,**
- Risk for the Environment,**
- Nuclear facilities.**
- The **standard risk facilities** include **four categories:**
 - Category I**, those with little risk for people and economy (example: sheds);
 - Category II**, those with standard risk (example: houses, shops);
 - Category III**, those with significant risk (example: residential buildings with more than 300 inhabitants, schools);
 - Category IV**, strategic facilities (example: fire brigades, airports...).
- The **environmental risk facilities** include all chemical, biological, oil & gas industries for which a risk outside the facility may be anticipated. For these facilities call *Facility with an Environmental risk*, in French using the acronym ICPE², two categories are described in the regulation:
 - ICPE self declared by the owner;

¹ This work has been supported by the French Ministry of Environment, Energy and Sea, and performed under an agreement between the Chemical Industry Owners' Association (UIC) and the French Association for Earthquake Engineering (AFPS)

² Installation Classée pour le Protection de l'Environnement

-ICPE needing authorization by the administration.
 This last category is divided in two:
 -ICPE with toxic inventory below the so-called SEVESO³ threshold;
 -**ICPE with toxic inventory above the so-called SEVESO threshold;**

We will discuss in this document only the implementation of the regulation for this last category.

- **The nuclear facilities** which shall comply to a specific regulation (site specific hazard study and design rule in elastic mode for a Safe Shutdown Earthquake level).

3. HAZARD AND DESIGN CRITERIA

Hazard is given as acceleration, the spectra is derived from recommendation of the design code.

For **standard risk facilities**, the design criteria is mainly "possibility of the inhabitants to escape", The reference acceleration for category II, for everybody's house is calculated as being the estimation of the 475 year return period earthquake (that could happen once in fifty years). Other categories are a priori values to be taken into account in the design calculations; the design criteria for buildings is stability; the regulation only applies to new builds.

For **high risk industries** the hazard shall take into account the ground properties and the design criteria is "no fatalities" at the first houses"; death can be from toxic material, heat or over-pressure effects; systems in the facilities are studied one by one. The regulation is to be applied for new builds; in addition retrofit for existing facilities is requested with a lower hazard level.

Nuclear facilities are designed on specific hazard analysis estimated for 10 000 years return period; in addition paleo-seismic survey is requested. The design is performed in order to bring the facility back in a safe shutdown state and maintain confinement of radioactive materials.

The table 1 below summarizes the hazard level and design criteria.

Table 1: Main hazard levels and design criteria for facilities in France (horizontal acceleration)

Facility category	Sub-category	Hazard criteria	Zone 1	Zone 2	Zone 3	Zone 4	Design criteria
Normal risk (new builds)	I (sheds)	-	0.8 x				Escape / Stability
	II (my house)	475 y return period	0,4 m/s ² rock	0,7 m/s ² rock	1,1 m/s ² rock	1,6 m/s ² rock	
	III (school)	-	1.2 x				
	IV (fire brigade)	-	1.4 x				
High risk industries (SEVESO) retrofitting	~ 3000 y return period	0.74 m/s ² rock	1.30 m/s ² rock	2.04 m/s ² rock	2.96 m/s ² rock	No fatalities induced by systems	
High risk industries (SEVESO) new builds	~ 5000 y return period	0.88 m/s ² rock	1.54 m/s ² rock	2.42 m/s ² rock	3.52 m/s ² rock		
Nuclear facilities	~ 10 000 y return period	Specific study				Integrity	

The normal risk facilities and high risk industries regulations request that the seismic hazard be graded according to the ground characteristics (coefficient 1 for rock up to 1.8 in seismic zones 1 to 3 and 1.4 in seismic zone 4 for soft soil).

The building code shall comply with the new Eurocodes (Eurocode 8 - Design of structures for earthquake resistance).

³ The name **SEVESO** was derived for the Italian city **Seveso** where -in 1976- a dioxin cloud escape from a manufacturing facility resulting in 193 contaminated people living close to the factory

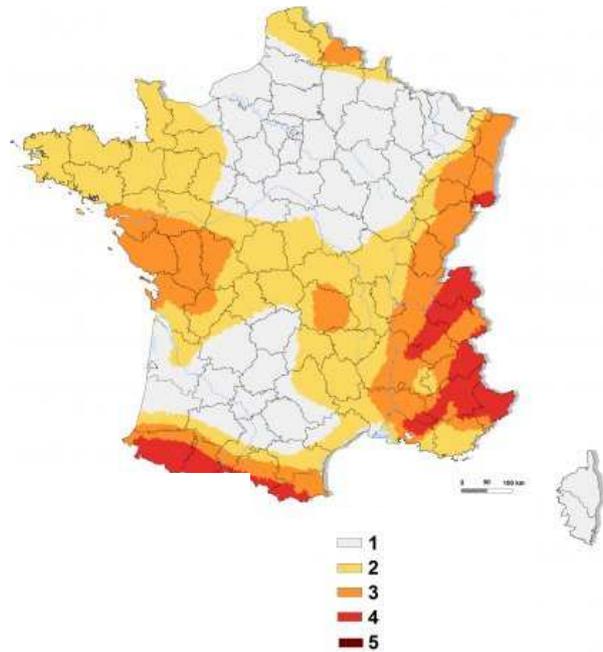


Figure 1 – Seismic zoning of France

4. ORGANIZATION FOR THE DEVELOPMENT OF REGULATIONS AND GUIDES

A working organization was set-up to develop a portfolio of implementation documents in order to ease the few thousands of local operators of high risk industries to upgrade their existing facilities and develop their new builds. This approach was necessary to perform an homogenous approach of the requirements and to ease local engineering offices which have no specific skills in seismic design.

The working organization consists of three levels:

- a **Supervision Committee** reporting to the Ministry,
- a **Leading Committee** (In French COPIL as PILot COmmittee) to co-ordinate activities,
- Working Groups** with representatives of the industry, research and design institutes and the French Association for Civil Engineering (AFPS) to develop the guidance documents in different fields.

The documents were reviewed internally by the scientific committee of the APFS, then by a technical support organization of the Ministry and finally validated by the Ministry and published on the website of the Chemical Industry Owners' Association (UIC) and of the Ministry. A case study was performed on two systems of two different facilities sited in two different seismic zones (1 and 3).

More than sixty people were involved in the development of the guidance documents. The work was performed over a period of three years (2012-2013-2014).

5. HANDBOOK AND MILESTONES

A set of six documents is now available (in French); they were developed both by the AFPS and the SNCT⁴ an association for boiler design and operation:

- The first document is called the **General Methodology Guide** (DT106⁵, 127 pages) which provides guidance in all the fields of implementation of the regulation (section II of the Ministerial rule of October 4th, 2010 updated)
- A side document gives orientation on how detection of the **earthquake may be used to put the systems of a facility in a safe shutdown state** (DT105) limiting any impact on the population below the regulatory threshold.
- Then, four design documents were produced:
 - Atmospheric storage tanks (cylindrical vertical & horizontal, cryogenic, DT109 to 110);
 - Support structures (DT111);
 - Pipes and valves (DT113);
 - Process material (DT114).

This set of documents was benchmarked on two facilities: a pharma-chemical production unit, close to Paris, in the very low seismic zone, and a chemical unit manufacturing nylon, in the seismic zone 3. Those tests demonstrated applicability of the methods but also highlighted difficulty to retrofit units in the very low seismicity area where the previous regulation did not required seismic hazard care (reference earthquake lower than 0.1g⁶). The second test uses automatic isolation valves to prevent releases from high volume horizontal storage tanks.

As a result of these case studies a set of checklists were prepared including one on site civil work conformity assessment for the two lowest seismic zones.

Having in mind that the design of such facilities were ruled by a 1993 Ministerial rule and based on these latest development and lessons learnt, the Ministerial rule was updated to define deadlines for the implementation of these new regulation and requirements. New facilities are to be designed according to the new rule but the retrofit of oldest facilities may be delayed until January 1st 2025.

6. CONCLUSION

Under the umbrella of the Ministry and geological offices, the regulations for all kind of facilities in France have recently been updated. A coherent and unique approach specifies now the requirements for all kind of facilities.

As far as high risk industries are concerned a package of technical documents has been developed under working groups of industry, research and development institutions and associations' representatives. It will ease the work of the engineering offices of the few thousands of such facilities operated today in France. Organization, validation process and benchmarking were the key issues for the success of this work. The AFPS, apart from its duties studying earthquakes and its consequences on buildings and mankind, contributes to the overall support to this activity.

⁴ Syndicat National de la Chaudronnerie, Tuyauterie et Maintenance industrielle

⁵ DT being the acronym of Technical Document, the number gives the reference of the document.

⁶ g is the acceleration of gravity (10 m/s²)